RECORDS

OF THE

SURVEY OF INDIA

Volume XII.

NOTES ON

SURVEY OF INDIA MAPS

AND THE MODERN DEVELOPMENT OF INDIAN CARTOGRAPHY

BY

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SUPERINTENDENT, MAP PUBLICATION.

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EXPLANATORY FOREWORD.

This paper was at proof stage in 1915, when, owing to the war, the preparation of the plates had to be put aside and the writer reverted to military duty. The intention was to complete the work and bring it up to date after the war.

It has, however, been decided to produce the paper now, and the writer's absence from the Survey of India for the last three years must be his excuse for its incompleteness and for the fact that it must be, in some particulars, out of date.

Several marked improvements in the methods of map reproduction have been introduced since the paper was written. Descriptions of these by Major F. J. M. King, R.E., who, with Mr. Vandyke's assistance, was mainly responsible for them, have been inserted as appendices.

W. M. COLDSTREAM, *Lt.-Colonel, R.E.*

London, September 1918.

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BY MAJOR F. J. M. KING, R.E.

NOTES ON
SURVEY OF INDIA MAPS.

CHAPTER I.

GENERAL DESCRIPTION OF INDIAN CARTOGRAPHY.

Early Government Maps.

Prior to 1802, the date of the measurement of Lambton's Madras base-line, when the Indian Government Surveys began to assume a more scientific character, such Indian topographical maps as existed were the results of reconnaissances, many of them merely route sketches, undertaken to assist or illustrate military operations. Conspicuous among these early maps are those of the celebrated geographer, Major James Rennell, F.R.S.: Rennell's "Bengal Atlas," "containing maps of the Theatre of War and Commerce on that side of Hindoostan" may be quoted as a specimen (see plate No. XII). Engraved in England and published in 1779, its maps on the scale of 5 miles to 1 inch are wonderfully full and accurate, considering the slender instrumental resources of the day and the fact that many of the surveys were carried out in war time in a hostile country.

The Survey of India may be said to have begun in 1767 when Major James Rennell was appointed Surveyor General of Bengal.

Design for a complete topographical map of India.

The normal scales of publication for the topographical maps of the country have been those of four miles and one mile to the inch. It was not till the latter half of the nineteenth century that any approach to a systematic scheme for the preparation of a one-inch map of India was attempted, but in 1824 the projection for the quarter-inch map*. known as the Atlas of India, was planned to cover the whole of the country in 177 sheets, each measuring 38 inches × 24·4 inches; the first sheet was engraved and published in England in 1827. The Atlas of India was compiled and drawn in the Surveyor General's offices at Calcutta and engraved in England until 1867, when the inconvenience of this arrangement led to the establishment of an engraving branch of the Calcutta office, where the sheets have since been engraved and printed. Shortly before this it had been found necessary to reduce the size of the sheets in order that publication might follow survey within a reasonable period, and, since 1864, the Atlas has been prepared in sheets one quarter the size of those originally projected and many of the old full sized sheets have been revised and re-engraved as quarter sheets.

Owing to the meagre nature of some of the older revenue surveys from which, in the absence of topographical surveys, the Atlas sheets had often to be compiled, some of the sheets cannot be said to be good topographical maps, but the great majority are of good quality and well engraved: they are printed in black only and the hills are shown by finely cut "vertical" hachures. (See plate No. XIII).

By 1905, when on the reorganisation of the Survey of India all work on the Atlas of India was stopped, practically the whole of India had been mapped on the quarter-inch scale,† and, until they can be superseded by the degree sheets of the modern series of maps, the Atlas sheets, although much out of date, remain the standard quarter-inch maps of India. For some parts of the country they are the only topographical maps available.

Unmethodical nature of the early one-inch mapping.

The magnitude of the task appears to have delayed any similar attempt to provide a uniform map on the scale of one inch to a mile. For many years the publication of the results of the topographical surveys, otherwise than as Atlas sheets, followed no systematic plan. Detached surveys were

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* Note.—The scale is not exactly 4 miles to 1 inch, being $\frac{1}{253,561}$ instead of $\frac{1}{253,440}$. The projection is one of the numerous modifications of the conical development.

† Note.—The Atlas of India was not extended to Burma where a series of sheets on the scale of 4 miles to 1 inch with margins limited by parallels and meridians took its place.

executed, and their maps, generally on the one-inch scale, formed separate series, the sheets conforming, not to the limits of a projected graticule, but to those of areas of administration. A typical example is the case of the Hyderabad Circar maps, published about 1844, in which the unit of survey and publication was the circar. (See plate No. XIX). In other cases the units adopted were districts or groups of districts, and sometimes, in the case of maps compiled from revenue surveys, the main traverse circuits from which the traverse framework of the survey was built up.

Introduction of systematic sheet framework by Provinces.

An important step in advance was taken in 1883 when it was decided to prepare Index maps for each province of India dividing the Provincial areas into standard sheets of 30 minutes of longitude × 15 minutes of latitude. The one-inch mapping since that date up to 1905, when the modern system was introduced, has been published in these standard sheets.

The Provincial series of old standard sheets are incomplete. In Madras few of the sheets have been published, and elsewhere there are large areas for which no one-inch maps exist. The old sheets will all eventually be superseded by the modern style sheets introduced in 1905, but for many years to come they must remain the standard one-inch maps for the greater part of India.

General position of Indian cartography before reorganisation, in 1905.

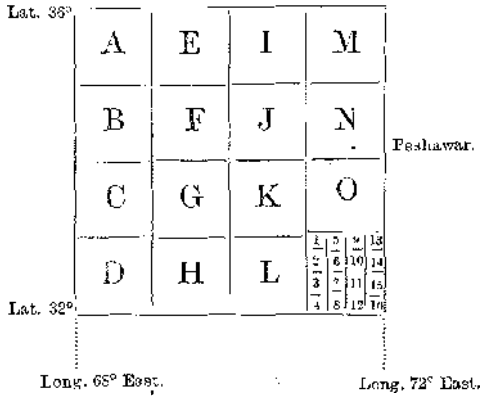
It has been shown above that the labours of the Survey of India in the 19th century had gradually resulted in the provision of a practically complete quarter-inch map of India and of partially complete provincial series of one-inch maps; but, while these may be considered the main objects of the Department's efforts, they represent only a portion of the century's output of mapping. Large areas which had been surveyed, more particularly for purposes of revenue and forest administration, had been mapped on the scale of 4 inches to 1 mile. (See plate No. XXXII). A series of engraved general maps of India had been prepared. Among these may be mentioned the 32-mile map, first published in 1881, (see plate No. II), and the 64-mile map first published in 1883, (see plate No. III). Some progress had also been made in the provision of a series of engraved provincial maps on the scale of 16 miles to an inch, (see plate No. VI) and many hundreds of special divisional, district, town and cantonment maps on varying scales were also in existence, (see plates Nos. XXXV and XXXVI). Outside India, nearly the whole of Persia and Afghanistan and a fringe of country round the northern and eastern Frontier of the Empire had been mapped approximately on various scales.

Reorganisation of Indian cartography.

The modern sheet framework.

With the commencement of the modern topographical survey of the country in 1905, a systematic scheme for Indian mapping was adopted. Under this scheme the whole of Southern Asia, between meridians 44° and 124°, east of Greenwich, and between Parallels 4° and 40°, North latitute, is divided up into sheets of 4° latitude × 4° longitude, on the scale of $\frac{1}{1,000,000}$, the sheets being numbered consecutively from the North-West. Each Indian $\frac{1}{\text{Million}}$ sheet is subdivided into 16 sheets of 1° latitude × 1° longitude, on the scale of 1 inch to 4 miles, known as degree sheets and lettered from A to P. Each degree sheet is, in its turn, subdivided into 16 one-inch to one mile sheets of 15′ latitude by 15′ longitude numbered from 1 to 16.

SHEET NO. 38, SCALE $\frac{1}{\text{Million}}$.



Thus, for example, the $\frac{1}{\text{Million}}$ sheet which includes Peshawar is No. 38, the Peshawar degree sheet is 38 N, and the Peshawar one-inch sheet is 38 $\frac{N}{12}$.

At the same time the long deferred adoption of the true longitude of Madras, namely, 18'-14'-54" East of Greenwich, was decided on for all Indian maps. This value is less than that used for the old maps by 2'-27·18", so that, while the modern one-inch sheets are just half the size of the old standard sheets of 30' × 15', their lateral margins do not coincide exactly with those of old sheets, and in all cases where a modern sheet on the east adjoins an old sheet on the west there is a gap of 2'-27·18" between the eastern margin of the old sheet and the western margin of the modern sheet. This is inconvenient but was unavoidable if the Indian Surveys were to join up accurately with those of other countries.

The new one-inch sheets.

The modern one-inch sheets, from which most of the other Indian mapping will be derived eventually, are drawn by the survey parties in the summer months following the winter season of survey, and are sent for publication to the Head Quarters Offices at Calcutta. The first sheets were published in 5 colours, red for roads and sites, blue for water, brown for contours, green for wooded and jungle areas and black for other detail and lettering, but in 1911 a sixth colour, yellow for cultivated areas, was introduced, and later, a seventh, grey for half-tone hill shading. As on American topographical maps, a distinction is made between water-forms that generally hold water and those that are generally dry, the latter being in black instead of blue. The roads are classified under six heads according to their suitability for different forms of traffic. Approximate contours are shown at 50 feet vertical intervals except in those mountainous regions where greater intervals are found necessary.

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CORRIGENDUM

Page 3, line 2, for 18° *read* 80°.

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cultivated and non-cultivated areas. The hills are shown by contours, generally at 250 feet vertical intervals, supplemented by hypsometrical layers and hill shading.

The new $\frac{1}{Million}$ sheets.

The series of $\frac{1}{Million}$ sheets is known as the "India and Adjacent Countries" series. The more recently published sheets are printed in black for lettering and sites, blue for water-forms and red for roads; the hills are shown by contours and hypsometrical layers supplemented by hill shading. Until the modern topographical maps extend over comparatively large areas the $\frac{1}{M}$ sheets have to be prepared from the old maps which do not show contours.

The $\frac{1}{2\ Million}$ sheets.

From the $\frac{1}{Million}$ sheets a series of sheets, each comprising 12° of longitude × 8° of latitude, on the scale of $\frac{1}{2\ Million}$, about 32 miles to 1 inch, was begun in 1909 and is known as the "Southern Asia" Series. These are layered maps in the same general style and colouring as the $\frac{1}{Million}$ sheets.

Present state of Indian cartography.

To sum up the present condition of Indian cartography:—(1) There are for the greater part of India old lithographed or photographed one-inch maps in sheets including 30' of longitude × 15' of latitude, without contours, but with hills shown by hachures or form-lines, printed in black only, or in black and brown. These are being superseded by contoured sheets of half their size, from modern surveys, printed in black and 4 or more colours. For the more highly developed parts of the country those modern sheets will be in two series, on the one-inch scale and on the half-inch scale respectively,

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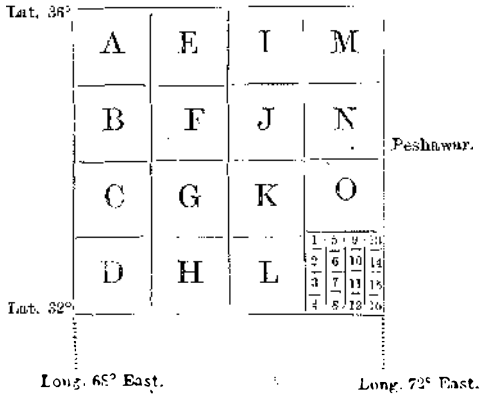

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The first sheets of the modern series appeared in 1907, and by 1915 over 1,100 were printed.

The new half-inch sheets.

It was at first intended to map the whole of India on the one-inch scale, but, for the less highly developed parts of the country, the half-inch scale has been found sufficiently large, and, as that scale has also been found to be the most suitable for general military purposes, the whole of India, including areas which have been, or will be, mapped in the modern one-inch sheets, will be mapped on the half-inch scale. The modern half-inch maps follow the general design of the modern one-inch maps in style and colouring.

The new quarter-inch sheets.

The degree sheets are compiled on photographic reductions of the one-inch or half-inch sheets and are, like them, published by heliozincography. They are in the same general style and colouring as the one-inch sheets but naturally are more generalised, for instance no distinction is made between cultivated and non-cultivated areas. The hills are shown by contours, generally at 250 feet vertical intervals, supplemented by hypsometrical layers and hill shading.

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The series of $\frac{1}{\text{Million}}$ sheets is known as the "India and Adjacent Countries" series. The more recently published sheets are printed in black for lettering and sites, blue for water-forms and red for roads; the hills are shown by contours and hypsometrical layers supplemented by hill shading. Until the modern topographical maps extend over comparatively large areas the $\frac{1}{M}$ sheets have to be prepared from the old maps which do not show contours.

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From the $\frac{1}{\text{Million}}$ sheets a series of sheets, each comprising 12° of longitude × 8° of latitude, on the scale of $\frac{1}{\text{2 Million}}$, about 32 miles to 1 inch, was begun in 1909 and is known as the "Southern Asia" Series. These are layered maps in the same general style and colouring as the $\frac{1}{\text{Million}}$ sheets.

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elsewhere they will be on the half-inch scale alone. (2) There is a practically complete series of engraved quarter-inch sheets, the Atlas of India, with hills shown by hachures in black only, which is being superseded by the 'Degree' series of contoured and layered quarter-inch sheets in colours. (3) There is a series, now practically complete for India, of sheets $4° \times 4°$ on the $\frac{1}{1\ \text{Million}}$ scale, in colours with contours, and layers. (4) A series of sheets, $12° \times 8°$, on the scale of $\frac{1}{2\ \text{Million}}$, in colours, with contours and layers, has been begun. (5) In addition, there is a series of engraved general maps of the country on the 32-mile scale and smaller scales.

The above are the standard or normal series of Indian maps.

CHAPTER II.

BRIEF SKETCH OF THE METHODS EMPLOYED IN THE REPRODUCTION OF INDIAN MAPS.

Early methods of reproduction.

During the first half of the nineteenth century the Indian maps were reproduced partly in England by engraving or lithography and partly in India by the latter process.

In 1867 the engraving of the Atlas sheets was transferred to Calcutta, but for some years previously the normal procedure had been to lithograph the other maps at Calcutta and Dehra, where the outlines were generally drawn on stone or on lithographic paper for transfer to stone, and the hills were drawn in chalk on stone. Many of the old lithographed maps were of considerable artistic merit.

Introduction of Photographic processes.

By 1866 it was found impossible to cope with the publication of the annually increasing number of maps by so slow a process as lithography, and photo.-lithography was introduced, to be followed a few years later by photo-zincography. The manuscript maps had now to be drawn specially for photography, generally on a larger scale than that of publication. They were photographed in sections, prints on transfer paper being joined up and laid down on stone or zinc. While this enabled the Department to publish its results within a reasonable period after survey, it necessarily affected the quality of the maps. The mezzotint hills were replaced by hills in line shading, and, in drawing and lettering, the photographed sheets were generally nferior to the artistic, if slowly executed, work on the lithographed sheets.

Introduction of colour printing.

By about 1895 the survey of hill features had become more detailed and accurate and the horizontal line shading of the field sheets began to develop into sketched contouring or form-lines at approximate vertical intervals of 50 feet.

Following on this improvement the use of colour was introduced, and the hills were drawn on a separate sheet of drawing paper to register exactly with the outline, and photographed to provide a brown plate.

Introduction of heliozincography.

The next step in advance was the gradual introduction of heliozincography, by which the maps were photographed in complete sheets and were printed directly from the negatives on to zinc without the aid of transfers. Heliozincography gave better results than photo.-lithography, was more convenient and methodical and had other advantages, but, until 1907, both methods remained in force.

Introduction of modern methods.

The question of extending the employment of engraving to the reproduction of the new one-inch map of India was seriously considered by the Survey Committee of 1905 but was abandoned on grounds of economy in the face of the enormous number of the sheets, some 6,300 being required to cover the Indian area, and of the fact that for a large proportion of the sheets there can only be a very small demand. It was, however, evident that some more elaborate and finished method of reproduction was required to do justice to the modern surveys than had sufficied for the old one-inch sheets, and, in 1906-1907, the Photo.-Lithographic Office was reorganised to enable it to turn out the modern coloured maps. These are now drawn on a scale one-half larger than that of publication on two sheets, for outline and contours respectively. If the map is to have hill shading a third shaded drawing is prepared.

Photozincography was finally abandoned in 1907 and all maps of the regular Indian series that are not engraved are now heliozincographed. Zincography is, however, still largely used in the printing of the engraved maps.

The colour plates for line work, other than contours, are obtained from separate negatives of the outline drawing, on which all work that is not to appear in the particular colour is painted out. The flat tints are laid down on "set-offs"* and, if there is a shaded drawing, the shade plate is procured by a special high light half-tone process for which the Department is indebted to one of its members. A brief description of the process of reproduction now employed for one-inch sheets is printed at the end of this chapter.

Reorganisation of the Photo.-Litho. Office.

The reorganisation was carried out under Major W. C. Hedley, R.E.,† an officer of the Ordnance Survey, whose services were lent to the Indian Government for the purpose. A few of the main features of the reorganisation may be mentioned, as without it the Department would not have been in a position to give effect to the numerous improvements in the design of its one-inch maps, nor would it have been able to undertake the preparation of the modern series of degree sheets, $\frac{1}{\text{Million}}$ sheets, $\frac{1}{2\text{ Million}}$ sheets and general maps which have been introduced of recent years.

Under the old system, the reproduction of the Indian maps had involved the taking of only two negatives for each sheet, the registration together of which had generally been imperfect; beyond touching up to remove dust spots no work had been required on the negatives, nor was there any special work required on the zinc plates, and the maps received only two printings in the machines.

Under the new system, each sheet involves the taking of five or six negatives‡, which must register together exactly, and a considerable amount of skilled labour is expended on each negative; some of the plates require the laying down of stipples or tints, while in many cases additional plates have to be prepared from "set offs", *e.g.*, for hypsometrical layer colouring, and the maps receive from 5 to 15 printings each. Moreover the new sheets being half the size of the old ones are twice as numerous for the same output of survey, while increased efficiency and establishments in the field parties have resulted in increased outputs. It is not too much to say that, at a conservative estimate, the quantity of work now done by the Photo.-Litho. Office is six times what was sufficient to meet the demands of the department before reorganisation, while a higher quality of negative, plate and impression is necessary.

Under Major Hedley's guidance the supervising establishment was strengthened, the office was divided into 2 main branches, (Photo. and Litho.), under responsible managers, the old routine was swept away and a new routine initiated, every section in the office was carefully overhauled, its methods modernised, and its staff trained and adjusted to the new demands and a new section of negative retouchers was recruited and trained. The increased efficiency obtained by these measures would, however, have been insufficient to enable the office to meet the increased strain without large additions to its establishments, but for a vital change in the procedure of map publication which greatly simplified the work.

Under the old system the final examination of a map was made on a proof of the sheet in the head-quarters offices of the Department. Minor mistakes, as must often be the case before a map has been finally examined, were numerous, the corrections were carried out on the zinc plates by an establishment of zinc draftsmen, and a fresh proof pulled and submitted to a further examination. It was rarely that press order was given without a 3rd proof being called for and there were numerous cases of maps being proved 6 or 8 times before they were printed. The corrections frequently involved references to the office where the map was drawn and such references took time and gave rise to correspondence.

Not only did this system involve serious delays in publication, but the plates deteriorated owing to the corrections made on them, so that the printed copies of a map were generally inferior to the first proofs in quality of impression.

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* This method is now followed only for the red and blue plates. The green and yellow plates are now prepared as described in Appendix I, last paragraph.

† Now Colonel W. C. Hedley, C.B., C.M.G., in charge of the Geographical Section of the General Staff.

‡ During 1918 this procedure was modified and only two negatives are now made in the Camera for each sheet,—one of the outline and one of the hills,—no prism being used on the Camera lens. Four reversed duplicates of the outline negative and one of the hills are made from the two original negatives by the "Powder" process, by means of which a negative can be made from a negative and by contact printing in a printing frame, the resulting negative being the reverse (right for left) of the original negative.

The final examination of a map is now made on the fair sheets themselves, before they are sent to the head quarters offices for reproduction. At first the new maps were proved twice over, preliminary proofs in black and brown and grey proofs for colouring, (as patterns for the colours of the map), being issued to the office responsible for the drawing of the sheet, and final proofs in colours being again sent out before printing. After a few years experience, it was found possible to do away with the colour proofs, and now the preliminary proofs in black and brown with grey proofs for the preparation of colour patterns are the only proofs issued, the reproducing office being itself held responsible for the correct colouring in accordance with the pattern.

Although the originals are now finally examined and passed before their reproduction, it is rarely that there are no minor alterations found necessary at proof stage, but these are generally of such a nature that they do not affect the plates seriously. In the exceptional cases where heavy alterations are necessary they are made on the fair drawings and the map is rephotographed to provide fresh plates.

Reproduction of engraved maps in colours.

It is only quite recently that Indian engraved maps have been produced in colours. One of the methods first tried experimentally was that of engraving the whole of the line work on one copper-plate and painting out in gamboge, or scraping out, the superfluous work from copper-plate transfers to provide a separate transfer for each colour, and then laying down the transfers to correct dimensions on separate zinc plates. The climate of Bengal with its sudden and marked variations in humidity rendered this plan quite unsuitable; it was found that by the time the transfers were painted out or scraped they had altered in size and could not be laid down to the exact dimensions, and it was only with great difficulty that the experiment was completed.

Another plan tried was to lay down the complete transfers on stone and remove the superfluous work from the stone to provide the different colour plates. Although this method was found to be workable the slow and difficult nature of the work on the stone led to its rejection.

The line work of engraved maps to be printed in colours is now engraved on separate plates, one for each colour. This expedites and simplifies the engravers' task and saves months of labour in the reproducing office. It has two disadvantages, namely, the absence of a complete copper-plate of the map from which extracts for special maps can be prepared, and the difficulty experienced in obtaining exact registration, for instance, between the black village site circles and the red roads on which they are situated, (see plate No. XI); the latter difficulty has, however, greatly diminished as the Engraving Office has gradually acquired increased skill and experience.

The method of obtaining separate colour plates from the plate of a map engraved entirely on one plate, by scraping copper matrices, is not available at Calcutta owing to the lack of a modern electro-typing plant, the existing plant being hardly sufficient to provide depositions for corrections.

Layer printing.

A few years after its reorganisation the Photo.-Litho. Office had to face the new task of printing layer maps (see Chapter VI).

In the absence of sufficiently large tint and ruling plates, the first experiment in layer printing had been carried out by a system of successive solid printings, which was soon recognised as unworkable in any but special cases. The number of printings and the expense and labour of preparing the numerous plates were excessive, considerable difficulty was experienced in obtaining sufficient transparency in colour, and a minor defect was that the map was apt to become saturated with printing ink so that the impression penetrated in some degree to the back of the paper. (See plate No. XXXIX).

In 1910 a series of large plates for tints and rulings were prepared. The single tints and rulings selected after experiments were nearly the same as those adopted at Southampton in 1913 for the International map. The Southampton key to the layer printing of that map however has shown the Photo.-Litho. Office that its methods of combining the different tints and rulings to obtain the shades of colouring required can be improved, and although the technical processes of Indian layer printing have yielded satisfactory results, it is believed that they may be simplified and further improved.*

As regards the selection of layer colours this is touched on in Chapter VI; no finality can be expected yet as the question is still a branch of cartography that is at the experimental stage.

Rubber-offset Printing.

By about 1910 the employment of rubber-offset printing for certain purposes had become general throughout the printing trade in Europe and America and it became advisable to consider its adoption for printing Indian maps.

The chief advantages at first claimed for the method were:—improvement in quality of impression, absence of the reversing prisms in photography, economy in ink and, most important, great increase in rapidity of printing. The last advantage is, however, confined to rotary-offset printing machines, which require a considerably longer time for changing colour and for the insertion of a new plate than flat-bed machines and are therefore unsuitable for printing Indian maps, of which the 'runs', or numbers of copies printed, are comparatively small, and the absence of a reversing prism and economy in ink are purely minor advantages. On the other hand, some of the disadvantages of rubber printing were obvious, *e.g.*, the concurrent working of different methods requiring different plates, for the old plates would still have to be reprinted by direct printing, difficulty in the examination of reversed proofs† and in training Indian printers in a process which is not very quickly and easily acquired by the best English printers. The question of the adoption of the process therefore turned entirely on whether better impressions could be obtained from rubber than from zinc. As the result of an enquiry made in England in 1910 it was obvious that rubber printing enabled good impressions to be obtained on rough or inferior papers which could not have been obtained by direct printing from zinc, but, on the point as to whether, if the best printing paper were used in each case, the impressions from rubber would still be better than those from zinc, the evidence was conflicting and it was evident that any superiority that existed was slight.

A convertible flat-bed, rubber-offset and direct zinc printing machine was obtained in 1913 and the new method carefully tested; the conclusion arrived at, after a year's experience, was that no better impression could be obtained on a good printing paper from rubber than from zinc, and it was accordingly decided not to adopt rubber printing for Indian maps.

Photo.-etching.

Photo.-etching on copper is a method of map reproduction superior to heliozincography. The impressions from photo.-etched copper are stronger and cleaner than from heliozincographed plates, although inferior to engraving, and, as the more important lettering, on which so much of the appearance of a map depends, can be, and generally is, engraved by hand on them, there is a finish in the appearance of the best photo.-etched maps that cannot be attained in a heliozincographed map. As the process is cheaper than engraving, although more expensive than heliozincography, a series of experiments was carried out at Calcutta to ascertain if it could be adopted for the reproduction of Indian maps.

The results were disappointing. They showed that while a slight improvement in outlining could be affected by photo.-etching when the ratio of reduction was increased to 2:1, the difference between a photo.-etched and heliozincographed map, when both were drawn for the normal Indian reduction of 3:2, was hardly appreciable and consisted chiefly in the absence from the former of very minute breaks in the impressions only of the finest lines, a matter of comparatively little importance. The photo.-etched lettering

* The process recently adopted is described in Appendix II.

† Offset proving presses which obviate this difficulty are now on the market.

showed very little improvement over good heliozincography, and to obtain a marked improvement, such as alone would warrant the adoption of a more expensive process, it was found that so much of the lettering would have to be hand-engraved that the map would begin to approximate in cost to an engraved map. Indian engravers can cut outlining comparatively well and quickly, but are slow in cutting names, so that if many of the names of a map had to be engraved it would be better worth while to engrave the whole map and thus obtain results superior to a map photo-etched in outline and engraved in lettering. It was accordingly determined to make no immediate change in the policy of engraving the more important of the geographical maps and reproducing all other departmental maps by heliozincography.

Ratio of scale of drawing to that of publication.

The normal ratio of the scale of drawing to that of publication in the Indian surveys has been alluded to above as 3:2. In the French African surveys, which work on somewhat similar lines to the Indian surveys, it is 5:4. The French maps are, however, drawn by men of education greatly superior to that of the ordinary Indian draftsman, who can be trained to draw well but rarely has much artistic touch in his work, and it is probably for this reason that he is found to require more assistance from the lens and camera than the French draftsman.

While, in India, 3:2 is found to be about the smallest ratio of reduction that will give satisfactory results, a ratio of 2:1 would undoubtedly give rather better results. There are, however, practical drawbacks in increasing the ratio much above 3:2. This would necessitate the fair maps being drawn in 2 sheets, thus increasing the number of fair sheets from 3 to 5*, with the disadvantages of increase in time required for pinning up the sheets for photography, difficulty in securing exact register between the hill drawings and the outline drawings, addition to the number of records and inconvenience in handling and storing the sheets, which already run into very large numbers.

Directions in which improvements in reproduction may take place.

At present there seems little chance of improving the quality of the negatives, but it is possible that something may be done to improve the helio. plates.

As is probably the case in every map publishing establishment, each process in use is subject to continual minor improvements. To enumerate these would be out of place in a general record of the development of Indian maps, but one direction in which further improvement is aimed at may be mentioned.

Owing to the thickness of the medium with which the negatives are painted to prepare them for the production of colour plates, when the negative and sensitised zinc plate are in contact in the printing frame under exposure to light, the diffused light is thought to cause a very slight but just perceptible blur in the edges of the lines produced on the plate. Experiments seem to show that this can be partly eliminated, if the printing frame is placed inside a room, otherwise darkened, and exposed to reflected sunlight thrown on to the negative at right angles to its surface. The amount of diffused light is thus diminished and the shadow of the edge of the duffing medium is done away with.

Special processes in use.

A very large number of special maps and diagrams are reproduced by the Survey of India for other departments of Government, and for a large proportion of these the Vandyke process is employed, by which the original drawing can be printed directly on to zinc, without the assistance of lens and camera. Invented by Mr. Vandyke, R.E., of the Department, this was the first successful form of the many varieties of "direct zinc" processes now in use all over the world.

Other processes in constant use for special reproductions are those of half-tone blocks, line-blocks and photogravure. For their application and for many improvements affected in these processes the Department is greatly indebted to Major-General Waterhouse, I.A., the well known authority on all branches of photography, who was for many years in charge of the photographic and lithographic work of the Survey of India.

*The shading would probably still be executed on the smaller scale, on one sheet.

CHAPTER III.

DEVELOPMENT OF INDIAN TOPOGRAPHICAL MAPS.

Early military reconnaissances. Rennell's maps.

An excellent specimen of the early type of small-scale topographical map prepared from military or geographical reconnaissance is the extract from Rennell's Bengal Atlas, shown on plate No. XII. It gives a successful representation of alluvial country; the main drainage channels stand out clearly, the existence of grass lands and marshes is shown without undue prominence, and the lettering, while it allows of a large number of village names being given, also gives due prominence to places of importance.

Extensive Indian military and geographical reconnaissances were made during the early years of the 19th century, chiefly in the South of India by Colonel Colin Mackenzie. The results were utilised in the preparation of some of the quarter-inch engraved maps known as the Atlas sheets, (see page 25 and plate No. XIII), but the original drawings are not forthcoming.

Rennell's maps and the old topographical maps of Southern India can, however, hardly be looked upon as the ancestors of the modern Indian topographical maps; their descendants appear in the sheets such as that illustrated in plate No. XIV and in the modern $\frac{1}{4}$-inch degree sheets of recently explored areas which are prepared from military or geographical surveys.

Hyderabad Circar maps.

The Circar maps of the Nizam's Dominions, prepared about 1840—50, (plate No. XIX), are among the earliest one-inch Indian maps prepared from regular topographical surveys extending over large areas. They are drawn with expression and character and the relative values of the items of information they give are well maintained. The depiction of ground features was still in its infancy in 1850. The short vertical hachures and the mezzotint shading unsupported by contouring, while they may give an idea of the gently undulating nature of the country, yield little accurate information in return for their tendency to obscure the map. The successful representation of cultivation by a reticule of finely dotted lines may be noted.

Captain Robinson's maps.

The modern method of plane-table surveying had its origin in India, and one of the earliest, if not the earliest exponent of the art was Captain D. G. Robinson of the Bengal Engineers, who surveyed large tracts of country in the north of India between 1850 and 1860. The original drawings on stone of Captain Robinson's maps are lost, and the specimen given in plate No. XXI, which has been photographed from an old print, is much inferior to the map as it was originally published. Much of the general style of Captain Robinson's mapping was retained for more than 50 years, *e.g.*, the blocked-in sites limited by sight-vane rays without any attempt at showing interior detail, the detailed depiction of ground features by line work, and the method of showing limits of cultivation, which is still that followed on Indian one-inch maps.

Early cartographical development.

So long as maps that were not engraved had to be drawn on stone or transfer paper for lithography, the use of mezzotint shading was available to assist in the representation of ground. The fair drawing being done by a specialist establishment, a comparatively high standard of lettering and

drawing was attainable and the impressions were clear and sharp. With the introduction of photozincography, while publication was expedited, the artistic qualities of the mapping fell off to some extent. Hills and slopes had now to be represented by line work alone, and the fair drawings were prepared by the surveyors and draftsmen of the party which carried out the survey, who necessarily varied in skill. Plate No. XXII. (U. P. 236, 1867), shows an early specimen of a map prepared in this way. The drawing of the roads and ornamentation and some of the larger lettering is irregular, the horizontal hachuring has the appearance of an attempt to produce the effect of mezzotint shading by line work and there is an absence of any indication of contouring about the hachuring. In spite of these disadvantages and the heavy nature of the black hachures, the specimen is a fairly successful representation of Himalayan country and the lettering and outline is less obscured than in many maps of 30 years later date.

Once photography was introduced in map reproduction, it was not long before the advantages of drawing for reduction began to be realised, and another advance was a tendency to draw the horizontal hachures as form-lines. Plate No. XXIII shows a sheet of 1874, which exemplifies both of these points. It also exemplifies a defect destined to crop up periodically in Indian cartography,—the endeavour to make all place names very prominent, which defeats its purpose by reducing the emphasis of the names of really important places.

Hachuring gradually gave place to form-lines and the artistic hand lettering of the older maps to typing (see plate No. XXIV). Many of the Bombay sheets of this period are very good examples of well drawn topography, showing nearly all the detail permissible by the scale, without the advantage of colour.

From this time, about 1880, on, until the reorganisation of Indian survey methods in 1905, the energies of the Survey of India, while as active as ever in the direction of field-work, appear to have weakened as regards cartography. The old-fashioned skill in hand lettering was lost, really good typers were not numerous and officers no longer had the time, nor, in all cases, the skill, to draw maps with their own hands, as many of the old school of survey officer had been accustomed to do. In the beauty and clearness of the maps, there was at any rate no advance and perhaps some falling off, but two distinct steps forward were gained; the form-lines gave place to approximate contouring, a vertical interval of 50 feet being aimed at on the one-inch maps, and a beginning was made in the utilisation of colour, by drawing the contours on a separate sheet and printing them in brown.

The one-inch sheets of Bombay (see plate No. XXIV) and other one-inch sheets of about the same period, had been surveyed and drawn on the two-inch scale, but between 1890 and 1905 most of the topographical surveys being in the less developed parts of Burma,* where a 2-inch scale was unnecessarily large for the survey, the advantages of surveying and drawing on a larger scale than that of publication were foregone and the maps were surveyed, drawn and published on the one-inch scale.

Old style standard sheets.

The old style standard sheet may be taken as assuming its final stage of development about 1895. From that time on until the reorganisation 10 years later, there was no advance in Indian cartography. Plate No. XXV gives a fair example of the sheets of this period, which were rather coarsely drawn maps, printed in black outline with very roughly approximate contours in brown. The lettering and symbols were, as a rule, unduly large; the main roads especially were enormously wide, thus displacing information in their immediate vicinity. The roughly approximate contours, which were barely more than form-lines, were drawn coarsely like the outline, with which they rarely registered exactly. At first it was customary to leave a blank space in the contouring for each name, a practice which entailed loss of information and emphasised defects in registration. A one-inch map prepared under these conditions gives practically no more information than a well drawn half-inch map will show.

* The more developed parts of Burma were generally surveyed cadastrally.

The defects in the old style standard sheets of the period immediately before the reorganisation of 1905 were, however, not entirely due to rough drawing and typing and to out of date methods of reproduction; they were, to a certain extent at any rate, deliberately aimed at, and due to the prevailing impression that as the maps were required for military purposes in the first place, a bold emphatic style of mapping was essential. The idea was frequently illustrated by the hypothetical case of an elderly General Officer with failing eye-sight poring over his map in bivouac by the light of a candle lantern. This mistaken striving after boldness and simplicity at the cost of completeness of information was to crop up again in the modern Indian mapping (see plate No. XXIX); it entirely overlooked the important principle that to give really important information due emphasis, it is necessary to keep down the emphasis of the less important information.

Revenue Survey maps.

So far, this discussion has dealt with the one-inch maps prepared from topographical surveys, but from an early date in the history of the Survey of India, one-inch maps have also been prepared from fiscal surveys. These surveys appear to have begun about 1857, and until about 1870 they were executed on the scale of 4 inches to 1 mile and known as 'Revenue Surveys'. Although in some cases they merely showed boundaries of village lands and little more, they were in other cases to all intents and purposes topographical maps. The field sheets usually included several adjacent villages, and were then termed 'congregated village plans'. They were sometimes artistically drawn in colours and appear generally to have been traced to provide copies for settlement and record purposes, but some of the later revenue surveys were reproduced to scale by photozincography (see Plate No. XXVI). Areas surveyed in this manner were not surveyed topographically, and later on their one-inch maps, where these were prepared, were obtained by pantagraphing down the village plans and fair drawing on the two-inch scale for reduction by photozincography.

The one-inch sheets thus obtained, some of which have not yet been superseded by more modern maps, were produced in separate series by districts and no attempt was made to complete the sheets outside the limits of districts.

Cadastral maps.

As land registration became more detailed and accurate, the old 4-inch revenue surveys were found inadequate for fiscal purposes, and large-scale surveys to ascertain and record the boundaries and giving the area of each field became necessary.

The cadastral surveys, as they are termed, began about 1870 and have almost invariably been executed on the scale of 16 inches to the mile, or 5 chains to the inch. A number of districts in what are now the United Provinces were surveyed by the Department in this manner. The cadastral survey parties, in addition to preparing 16-inch plans of the lands of each village, also prepared the records of rights, giving information regarding the boundaries, areas, crops, tenure and ownership of each plot of land, and fair drawings on the two-inch scale for the preparation by photozincography of one-inch topographical maps. The system of professional cadastral surveys, which began in the United Provinces, was extended later on to Bengal, Assam and Burma. The execution of cadastral surveys has, however, been gradually taken over by the local governments, several of which have now each its own survey establishment working in close touch with, or as part of, its settlement and revenue departments. So long as cadastral surveys were carried out by professional survey parties which were responsible for the preparation of 1-inch maps from them, it was possible to prepare good topographical maps of plains districts from the 16-inch plans, and this is still the case to some extent where cadastral surveys are controlled by officers of the Survey of India and the requirements of cartography are borne in mind by the surveying establishments. Cadastral surveys, however, being primarily concerned with the record of rights need take little account of ground features or topographical details that do not form boundaries; it is only possible to obtain good one-inch maps from them under favourable circumstances in absolutely flat country, and the topographical maps prepared in this way vary very greatly in quality.

The specimen given on plate No. XXVI may be taken as a fairly typical example, and that on plate No. XXVII as an exceptionally favourable example of this class of Indian topographical map. At their best, such maps are defective in the information they give regarding heights, ground features, vegetation and the permanent or temporary character of water forms.

Before 1907, when the new style of topographical map began to be published, the one-inch sheets of the more densely populated flat plains areas in India were, as a rule, prepared from cadastral surveys and superseded the old maps based on the 4-inch revenue surveys; elsewhere they were based on topographical surveys. Whereas the sheets reduced from the 4-inch revenue surveys had been prepared in series by districts, most of those from cadastral surveys and from the later topographical surveys were published in a standard size of 30′ of longitude by 15′ of latitude in provincial series (*vide* Chapter I, page 2).

Introduction of new methods.

Towards the close of the 19th century, improvements in methods of reproduction of drawings, including those of colour printing, had given cartographers much wider scope in the depiction of country and had enabled them to show more information on their maps than it was possible to show clearly by the old methods. The Ordnance Survey of the United Kingdom and the national surveys of most of the other powers had already taken advantage of these improvements, or were beginning to do so, and while Indian surveys were still considered in many respects as models of topographical work, their published results, the old-style standard sheets, were in quality and appearance greatly behind the times. In order to remedy this and to decide on a methodical policy of survey methods and programmes, a commission of administrators and experts was appointed by the Secretary of State for India in 1905. On the recommendations of this committee an improved system of cartography was introduced.

Size of sheets.

The size of the new standard one-inch sheet was fixed at 15′ of longitude × 15′ of latitude, just half that of the old sheet. This was considered advisable in 1905, in order to facilitate registration of colours, but as little serious difficulty in obtaining registration on sheets as large as 40 inches × 30 inches is now experienced, this consideration has ceased to have much weight. For use in the field a small sheet is convenient to handle, but it is open to question whether this advantage is not outweighed by the inconvenience of having to carry a larger number of sheets and of the rapidity with which the user of the maps, be he military officer or touring official, passes out of the area of a small sheet in the course of his work. So far as the Indian topographical maps are concerned, the question of size of sheet is at present one of merely academic interest because the whole system of sheet numbering depends on the size adopted and could not be changed without the risk of confusion and the certainty of great inconvenience to the map-using public. It is, however, different in the case of the smaller scale geographical maps; the argument of convenience of handling hardly affects the case with maps for desk or office use and does not affect it at all with wall maps. In these cases advantages are all on the side of the large sheet, subject, however, to the technical consideration that the greater the number of sheets in which a map is engraved, the more engravers can be employed on it and the more quickly can it be published. A convenient size of sheet for a geographical map is that adopted for the International Map of the World and the Survey of India has followed it in the design of the new $\frac{1}{2 \text{ Million}}$ maps.

Reasons against engraving.

The topographical maps of several of the other national surveys are engraved on copper, and while no photographic process can quite equal engraving in clearness and beauty, the following considerations led to the decision that the Indian topographical maps should be reproduced by photography :—

(*i*) *Economy.*—Engraving is a costly process, the number of topographical sheets required to cover the Indian Empire runs into several thousands and for a very large proportion of these there can be only a small demand.

(*ii*) *Rapidity.*—The annual output of 1-inch sheets alone is about 200,* and, while this number can be dealt with comparatively easily by photography within the year following that of survey and drawing; if the sheets were engraved, publication would be delayed for at least another year, unless an exceedingly large staff of engravers were entertained.

(*iii*) *Facility of correction.*—The enormous area of India precludes complete revision surveys at frequent dates. The present survey will last for more than 30 years, and in that period many changes due to the development of communication and canals will have to be given effect to on the more important sheets. It is a simpler matter to correct a drawing and rephotograph it than to correct a copper plate.

(*iv*) *Improvements in photographic processes.*—With good drawing, photographic reduction, the best lenses and careful printing, maps photographically produced are not now so greatly inferior to engraved maps as they were. Indeed, if none but very highly skilled and experienced draftsmen were employed and the maps were drawn on at least double the scale of reproduction, a photo.-etched map or even a heliozincographed map would approximate in clearness and beauty to an engraving, although to attain this standard of excellence the advantages of economy and rapidity would have to be very greatly foregone.

The photographic process adopted by the Survey of India and introduced by Colonel Hedley, R.E., an officer of the Ordnance Survey whose services were lent to the Department for 2 years in 1907, is that of duffing the negatives for colours and from them preparing zinc plates by heliozincography (see Chapter II).

Selection of colours.

The new one-inch sheets were at first printed in the following colours only:—

Red for roads and sites of towns, villages and buildings.

Blue for water-forms of a permanent nature, and their names.

Green for wooded areas.

Brown for contours and their values and for depiction of broken ground intimately connected with the contouring.

Black for other information, and the mass of the lettering.

Within certain conventional limitations, namely, the representation of water by blue and the use of black for ordinary lettering, the choice of colours in the design of a map is still to a great extent a matter of opinion, and practice in different countries differs. The American plan of retaining black for the works of man (or artificial detail), brown for information regarding ground features and blue for all water-forms is logical and simple, and, as such, has great advantages. It does not, however, place the full resources of colour printing at the disposal of the cartographer and the beautiful maps of the American Geological Survey, while clear and artistic, do not give the complete information of other national topographical maps, which utilise, in addition to these three colours, green, red and grey. As well as the recognised conventional use of blue, certain other considerations affect the selection of colours. To facilitate registration it is convenient that the outline of roads and buildings should be in the same colour, and that contours and precipitous ground should be in the same colour, while it renders the map more clearly legible in its crowded portions, if names, roads, contours and streams are printed in different colours.

The selection of colours for the modern Indian topographical maps satisfies these considerations. It has been criticised on the ground that it leaves comparatively little information to be shown in black and that the main outlining

*This number has been very considerably reduced during the war owing to the curtailment of the survey programme.

of a map should be, as much as possible, in black. To meet this objection, the roads, or at any rate their outline, could be printed in black, but in this case, to ensure perfect accuracy in the agreement of sites and roads, the sites and buildings also should be in black or black rulings with the disadvantage that black lettering would not show up well on them. Opinions differ as to which plan has the balance of advantage; good topographical maps can be made on either system; those of the French Service Géographique de l'Armée, the Italian Military Institute and the Survey of India are examples of red roads and sites, and those of the Ordnance Survey and the American Geological Survey, of black roads and sites. The Ordnance Survey have combined the advantages of both plans by filling in the important roads on their maps in a red brown.

Water-forms.

The modern one-inch sheets began to appear in 1908. Plates Nos. XXVIII and XXIX show examples of the map as first designed. The latter is exceptional in its heavy style of drawing, due to a temporary recrudescence of the attempt to make all information bold and prominent; plate No. XXVIII. may be taken as typical. On the modern maps permanent water-forms are distinguished from those of a recurrent or temporary nature, and at first, areas covered only temporarily by water were shown by blue dots, those covered permanently being shown by a blue stipple or tint. An example of this may be seen near the top margin of plate No. XXVIII. The large tank at Kutása is not always full, the permanent water is confined to the small artificial tank within its area. The blue dots were soon abandoned, their meaning was not obvious; in large areas they were unsightly and in small areas, *e.g.*, narrow beds of streams, they were difficult to distinguish from the blue stipple of permanent water. Temporary water-forms are now shown uncoloured; see the dry channels in the N.E. corner and N.E. of the city site on plate No. XXXI.

Blue lettering.

Another change in the application of blue was in the colour of the lettering of water-forms; at first water-form names were printed in blue (see Purna River on plate No. XXVIII). Blue is a difficult colour to print very sharply and clearly and the blue lettering was apt to spread and block up a little; also it is obviously desirable to enter the name of a large river or lake within its area, and black shows up better than blue over a blue tint. Names of water-forms are now shown like other lettering in black on Indian topographical maps, although they are still shown in blue on the geographical maps (see plates Nos. V, VIII and XI A), on which, owing to the smallness of the scale, the lettering is apt to be more crowded than on topographical maps and the colour distinction is therefore more valuable.

Margins of blue areas.

Unlike many of the modern topographical maps of other countries the Indian one-inch sheets show the margins of blue water areas in black instead of blue lines, except in the case of tidal waters. The argument for deciding on this departure from modern usage is that in India it is particularly desirable to distinguish between permanent and temporary water-forms; the latter are shown in black, and where dry channels run into double line permanent streams, when the margins of the permanent stream were shown in blue, the change of colour was considered unsightly and misleading because it gave the less important channel more emphasis, being in black, than the main stream margins in blue. There is another argument in favour of black water margins. On the Indian one-inch and half-inch maps the character of river, lake and tank banks is indicated by the thickness of the line, which represents both the margin of the water and the bank, if a bank exists close to the water's edge. A steep high bank, up which guns could not be driven, is shown by a thick line, the relative height of the bank being entered in feet; where the bank is shelving a fine line is used for the water margin. With blue water margins this method would hardly be suitable and, if the bank were shown separately from the water margin, it would necessarily be displaced. An alternative course would be to show no line at the water margin, and this plan is employed where the margin of permanent water in a tank is of a fluctuating nature; it has, however, the technical disadvantage that it gives no guide on the plate for the application of the blue tint, which, though it has little importance in the case of tanks would be serious in the case of rivers.

In order to follow modern usage in outlining blue areas by blue lines, experiments were made to try the effect of obtaining the distinction between permanent and temporary streams by showing the latter in broken blue lines. On the American maps this plan answers well, but in India, where, in the area of a one-inch sheet, temporary channels may be far more numerous than permanent ones, it was found to give the experimental sheet a very unfinished appearance and for this reason the plan was abandoned.

In the designs of the modern quarter-inch map and geographical maps, which were made some years after that of the one-inch map, the prevailing custom was followed; the margins of blue water areas on these maps are blue lines. The new half-inch map, however, follows the one-inch map in this respect.

The arguments for black water margins have less weight in the case of the quarter-inch scale than in that of the one-inch scale, while they do not apply in the case of geographical maps, as all water channels, whether of a temporary or permanent nature, are shown on them in blue and the scale precludes the representation of the character of the banks.

Blue stipples and rulings.

On Indian maps blue flat washes are printed in stipples or rulings instead of in solid blue. This occasionally makes it difficult to obtain the strength of blue required, but a blue printing ink that will keep its colour when printed as a solid wash has yet to be found. If printed solid over an area, blue fades to a dull green after exposure to light; if printed in a stipple or tint it still fades, but it does so very slowly.

Coast-lines.

The coast-line on modern Indian maps is the line of high water of mean tides, and is now shown by a continuous blue line* up to the limit of tidal water. The line of low water of mean tides, where it is not too close to the high-water line to show separately, is indicated by a dotted blue line, which also forms the margin of the blue stipple printed over the sea. The plan of extending a blue stipple, but of a lighter shade than the blue of the sea, over the foreshore, including its 'details', such as sand, rocks, channels, light-houses, &c., each in its appropriate colour, was tried, but given up because, while it added to the cost and labour of preparing the blue plate, being an extremely narrow strip, it was hardly distinguishable from the blue of the sea. The 5-fathom and 10-fathom lines, which are taken from Admiralty Charts, are shown in blue dotted lines and lettered in blue, this being the only blue lettering now shown on one-inch maps.

Snow and ice.

It is only quite recently that the modern topographical surveys have been extended into regions which are permanently covered by snow and ice. Perpetual snow, except in snow beds below the snow line, is not shown, but each one-inch or half-inch sheet which includes areas of perpetual snow bears a foot-note stating the approximate height of the snow line. Glaciers are outlined in broken blue lines and are not contoured, but their forms are indicated by blue form-lines.

Information shown in red, town and village sites.

One of the most important changes in the design of the modern one-inch map has been in the depiction of town and village sites; these were at first shown in solid bright red blocks and were rarely surveyed in much detail (see plates Nos. XXVIII and XXIX). The effect of this on sheets which contained numerous large sites was unpleasing to the eye, and the plan had another serious objection in that if the sites on the fair drawings are blocked in, it is not possible to type their names over them. Town and village sites are now surveyed and drawn in more detail and are shown in red outline, filled in with a light red stipple (see plates Nos. XXX and XXXI). Single buildings and groups of huts too small to show to scale are, however, still represented by small blocked-in red squares. For maps such as the Indian topographical maps, which are prepared from topographical surveys on the same scale as that of publication or on scales only slightly greater, it is not possible to attain the very detailed depiction of town and village sites shown by maps such as the Ordnance Survey sheets, which are reduced from surveys executed on a scale enormously greater than that of the topographical publication.

* "A coast line differs from a lake margin in that the level of the water rises to it only at high tides; in a lake there is no tidal rise and fall. Blue is, therefore, considered a suitable colour for a coast-line, although lake margin are shown in black". [Extract from Surveyor General's Orders].

While the recently adopted tinted sites are undoubtedly more artistic and restful to the eyes than the glaring red sites of older sheets, it is open to question whether the decline in emphasis due to their more subdued colouring has not been carried almost too far. The quarter-inch degree sheets published up to date differ from the one-inch sheets in the depiction of sites. The degree sheets have hitherto been the military maps of the country and at the special request of the military authorities all town and village sites and symbols for buildings are shown in black on these maps*. As the military authorities did not desire a similar change in the colouring of roads, the difference in colour between buildings and roads considerably augments the difficulties of registration, a very slight error in which may place a building, situated on one side of a single line road, across the road, or remove it appreciably from the road.

The modern Italian $\frac{1}{100,000}$ map, the first sheets of which began to appear in 1911, some years after those of the Indian 1-inch map, indicates the approximate population of each town and village. This plan has not yet been adopted on Indian topographical maps although it is followed to a certain extent in the case of $\frac{1}{\text{Million}}$ maps; it has obvious advantages, but hitherto these have not been considered to outweigh the interference with other information which it might entail.

As mentioned above, roads are shown in red. Their classification and symbols will be dealt with later on under conventional signs.

Reference letters and numbers.

In order to facilitate references to the location of places, reference letters and numbers are printed in red in the margins of the sheets of all modern Indian series of maps, the letters being used to define the zones of longitude and the numbers the zones of latitude formed by the graticule of meridians and parallels, which are printed across the face of the map, at 5′ intervals in the case of 1-inch and half-inch maps, and at 15′ intervals in the case of degree sheets.

Information shown in green, trees and woods.

The depiction of wooded areas on the new maps was the subject of many experiments. Green tree symbols, like those on the Canadian one-inch maps prepared by the War Office were tried, but the balance of advantages was considered to lie with a green flat tint combined with black tree symbols, as on the Ordnance Survey one-inch sheets. At first, dense woods and jungles through which troops would find it difficult to work, were distinguished from open woods by being coloured a darker shade of green. The practical difficulty in defining the limits of the dense forest areas and the consequent unreliability of the information it was intended to give by this method led to its abandonment, and the more densely wooded areas in forests are now merely indicated by the greater number of tree symbols shown. The trees were generally omitted from woods on steep hillsides, where they have been considered likely to confuse the map, but this is now generally thought to have been a mistake, as tree symbols, if small and finely drawn, rarely interfere with other information on a map.

The shade of green first adopted was approximately that of the woods on Ordnance Survey maps (see plate No. XXVIII), but though successful on the British sheets, which rarely, if ever, are wooded to the extent of one-tenth of their areas, it was found too bright for Indian sheets which are sometimes entirely covered by woods. Its yellow tint was apt to 'kill' the other colouring, and after many experiments, the present cooler shade of green was adopted (see plate No. XXXI). There was, at first, no intention of printing ribbons of colour along boundaries, but the practical importance to map users of the Reserved Forest boundaries has led to their being outlined in green. This plan has serious drawbacks; the Reserved Forest boundaries are, in some ways, the least important boundaries shown, and the green lines undoubtedly affect the appearance of the maps very adversely, but the laws regarding shooting, wood-cutting, &c., in Reserved Forests make it desirable that their boundaries should be prominently marked. No other boundaries are printed in colour on the topographical maps, but, when specially asked for, copies of maps are hand coloured in this respect before issue.

* The chief reason on which this request was based was that the red colour gave undue prominence to small hamlets in comparison with ground features.

Information shown in yellow. Cultivation.

The extent of cultivation is an important item of information on Indian maps. On the old standard sheets, and on the first few years' issues of the modern one-inch sheets also, cultivation was shown only by its limits in fine dotted lines and by the absence from the cultivated areas of surface characteristics, *e.g.*, sand, rocks, natural vegetation, &c. (see plates Nos. XXIV and XXVII). This method, however, failed to convey the cultivated or uncultivated character of the country at a glance, and in 1911 it was decided to print a flat wash of yellow over all cultivation (see plates Nos. XXX and XXXI); a plan which, combined with the careful depiction of surface characteristics, has been found very successful in enabling the map user to form an accurate impression of the nature of the country.

Representation of hills. Contours.

The most marked improvement in cartography of late years has been in the representation of hills and ground features. The modern one-inch maps are contoured normally at 50 feet vertical intervals*, the contours and their values and precipitous or broken ground intimately connected with contouring being printed in brown.

The normal vertical interval of 50 feet is in accordance with the general practice of modern British and American topography and military sketching under the empirical rule :—

$$\text{Contour Interval} = \left(\frac{50}{\text{Scale of map, in inches to the mile.}}\right) \text{feet.}$$

In India, however, mountainous country requires exceptional treatment. To contour the Himalayas on the one-inch scale at a vertical interval of 50 feet would give practically no more information than to contour them at 100 feet and would only result in obscuring the information the map is intended to give. The 100 feet vertical interval has therefore been adopted for Indian one-inch maps of mountainous country, and where this fails, as in the flatter portions of the sheet and at summits and ridges, to depict the features of the ground, form-lines are employed to mark important changes of slope and define the summits of peaks and ridges.

The accentuation of certain contours at uniform intervals by thickening is now customary on the topographical maps of most of the national surveys. It has the advantage of assisting the eye to group and mass the larger features, and the slight disadvantage of giving them a rather conventional and stepped appearance. On Indian 1-inch maps every fifth contour, (at 250 feet, or, in the case of mountainous country, at 500 feet intervals), is accentuated in this way.

The contours are broken for contour values. Opinions differ widely on this question, but breaking the contours has the merit of defining with certainty, even in steep ground, the contours to which the values apply. The plan of always placing the contour value immediately on the uphill side of the contour affords a ready means of distinguishing the direction of the slope, but the convention is not an obvious one, it is difficult to follow in steep ground; and on well drawn maps, especially if the contouring is supplemented by shade and all main drainage channels, wet or dry, are shown, there is no difficulty in distinguishing the direction of slope at a glance.

Spot heights, unlike contour values, are shown in black and those that are only approximately accurate are distinguished by being typed in sloping figures.

The selection of a suitable brown for the contours has been the subject of several experiments; the brown now in use is a mixture of umber and burnt sienna, the former colour used alone is too dark and the latter used alone gives a yellow tone to the sheet and clashes with the yellow of cultivation and the green of woods.

While the contours convey practically all information regarding the shape of the ground that is obtained by the survey, it is only exceptionally, in the case of large strongly marked definite features, or of very regular unbroken country, that the general morphology of the region is obvious at a glance, on

* The contours are approximate, that is they are not traced by levelling, but are interpolated in the field from large numbers of spot heights obtained by the clinometer.

a map which shows the shape of the ground by contours and heights alone. This is the case to some extent even when the map is looked at by an expert but it applies with much greater force when it is looked at by a person not specially trained to read maps.

It is true that, by adopting a very small vertical interval, contouring in itself can be made to give some impression of relief, and this plan is often wonderfully successful on the maps of the American Geological Survey, where the contour interval is only 20 feet on a scale of approximately 1 inch to 1 mile, but it is apt to involve either the omission or the partial obscuration of information.

Hill-shading.

For these reasons, on modern topographical maps the contours are generally supplemented by hill shading of some sort. This gives the effect of relief, masses the main features to the eye and is an advance in the direction of making the topographical map an easily intelligible picture of the country it represents.

The choice of a suitable system of shading is not a simple matter. For large scale topographical maps, such as the one-inch map, there are several systems or combinations of systems available. Illumination may be assumed to be vertical or horizontal and, if the latter, it may be assumed from any direction. The depth of shade may be made to vary with steepness of slope or, in the case of horizontal illumination, it may be uniform, with edges shaded off, or left hard and definite. The spurs and ridges on the unilluminated sides of the main features may be independently shaded or subordinated, as sub-features, to the shading of the main features and it is often difficult to decide what is to be treated as a sub-feature. Again, although this principle is more applicable to small-scale geographical maps than to topographical maps, the depth of shade may be varied with the height and importance of the feature. Many of these questions are matters of opinion, and the application of shading may be treated merely as a pictorial art or as the scientific following out of a rigid principle. If the sheets of a topographical map could be dealt with independently, a different principle or system of shading might be advisable for each according to the nature and trend of the hills in it.

The advantage of vertical illumination, with shade varying according to steepness of slope, is that it conveys definite information and is scientific and logical. The method is suitable for the shading of topographical maps on comparatively large scales, *e.g.*, 4 inches to 1 mile, or of uncontoured maps on scales not less than about 1 inch to the mile, but on any but large scale maps it is distinctly less artistic and conveys less impression of relief than horizontal illumination, and, unless very well executed, is apt to result in stiff regular bands and discs of white along ridges and valleys and on summits. The advantage is discounted largely when shade is used merely as an adjunct to contouring; in this case the contours give the scientific information while the shading is only explanatory and intended to give the effect of relief.

The most suitable direction of horizontal lighting, to show up the features and give the best effect of relief must vary with the trend of the main features in the sheet. For the greater part of the Himalayas, a south-westerly or north-easterly illumination would be the most effective from this point of view, while a southerly illumination may be considered as the most true to nature for country in the northern hemisphere. On the other hand the natural lighting for the examination of a document or picture held in the hand is from the top left-hand corner and, probably for this reason, the ordinary convention is to assume the direction of light to be from the north-west. A perhaps rather far-fetched argument that has been adduced in favour of the westerly direction is that hill country is best seen and sketched when the sun is rather low, and hill views are more familiar and more easily visualised with the sun low in the west.

With horizontal illumination, it is obvious that the sub-features of a hillside facing the light should receive no shading, except where they begin to turn away from the direction of the light, and that the shading should cross from

one side of a range to the other with every marked change in the direction of the range, but experiments show that with a fixed direction of illumination much of the artistic and explanatory effect of shading is lost and that it is desirable to allow a certain latitude in varying the direction of illumination within a sheet.

Theoretically, with horizontal illumination the depth of shade should be uniform and not vary with the degree of slope. If this principle is strictly followed it is found that the sharp defined edges of shade along the tops of gently rounded spurs or ranges and along the gently sloping foot of a hill may be very misleading. Again, experiments have shown that while it is important to use the shading in order to mass the main features to the eye, sub-features on the unilluminated sides must be shaded to some extent independently or the effect is apt to be flat and inartistic.

Taking into consideration all these factors, the style of shading adopted on the modern Indian topographical maps is one of compromise. It assumes a horizontal lighting from the north-west, but with latitude to shift the direction a little towards the north or south, where this is required to show up the features of the ground. The shading is uniform in depth, but, while its edges are left hard and definite along sharply defined crests and ridges, they are shaded off at the tops of rounded features and the gently sloping foot of a range or spur; also, while the unilluminated flanks of the main features are shaded without reference to the minor sub-features, the major sub-features are either treated independently or receive on their unilluminated flanks a reinforced depth of shade.

The shading on the latest one-inch sheets still varies greatly in quality and aesthetic execution*, but, even in the least successful cases, it is recognized as a marked improvement to the map.

The best method of applying the shade is by brush work, but it is only the exceptional Indian draftsman that can be taught to use the brush rapidly and well, while any good draftsman can be taught to do stump shading. The great amount of this class of work that has fallen on the drawing establishments since the introduction of shading has rendered it impossible to employ brush work if the maps are to be published promptly, and the shading is generally executed by stump in chalk or lead pencil.†

It is, however, hoped that as draftsmen become more skilled it may be found possible to extend the employment of brush work to the shading of all the more important maps.

The shading is carried out on blue prints of the contours and outline combined, prepared by what is known as the "dust on process" in which the impression is obtained in light blue powder which can easily be obliterated before photography. This is necessary as some of the blue lines reproduce faintly and can not be duffed out from the screen negatives.

Hypsometrical layers.

Experiments in the direction of a still further elaboration in methods of hill depiction on the one-inch sheets, by the adoption of hypsometrical layer colouring, have been carried out (see plate No. XL). If the one-inch sheets were layered it would, however, mean the loss of the advantages gained by showing wooded areas in green and cultivated areas in yellow, and it would increase the number of printings, a somewhat serious matter in view of the enormous number of one-inch sheets to be produced. For these reasons there is no intention at present of extending the 'layer' system to the one-inch sheets.

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* NOTE:—Indian draftsmen can rarely shade a sheet unassisted, but if given a rough guide showing where the shade is to be applied they can apply the shade well.

† A serious drawback to stump work is that it loses brilliancy and, where a new edition of a shaded sheet has to be produced, if new negatives are necessary, the shaded fair sheet must be touched up to restore it before photography.

Conventional signs.

The free use of colour printing and the general refinement of drawing, which were introduced into Indian cartography with the modern one-inch maps, necessitated numerous changes in symbols. These were made in consultation with the Indian General Staff, the one-inch sheets being at that time the tactical maps of the country.

Railways.

Some of the more important changes may be mentioned. The old single line with short transverse lines which was formerly used for a railway, was superseded in the case of ordinary railways, by the chequered symbol (see plate No. XXXI), and was retained for light railways only. The old symbol (see plate No. XXVI), is disappearing from maps in most countries and the modern tendency is to employ a single black line, especially on maps on which railways are not classified (see plate No. XI).

Embankments.

Vertical hachuring (see plate No. XXX), was substituted for the double-line crossed by diagonal rulings (see plate No. XXXII), which represented a "bund" or artificial embankment, except in the case of low "bunds" which are now shown by single black lines, with their heights in figures, in the same way as steep banks or scarps that are not sufficiently high to show by hachures.

Roads.

At the request of the General Staff, roads were classified in six classes according to their suitability for military transport, and the three more important classes were at first shown by double lines. The modern tendency in the representation of roads is to abandon the double-line symbol because it necessarily displaces detail along the road and can not be used to show bends and the plans of cross roads as truthfully as the single line. Double lines are still retained for main roads on Indian topographical maps but the symbol for a village cart-track was altered in 1912 to a single line. Village cart-tracks are extremely numerous; in some parts of the country every village site is a *nexus* of many tracks which cannot be accurately shown by double lines. On the other hand, main roads are comparatively rare in India, so that the defects of the double-line symbol do not seriously affect the maps, while the symbol helps to give such roads the emphasis they should have. In order still further to increase the emphasis of metalled roads they are now filled in with a red tint (see plates Nos. XXX and XXXI).

Before leaving the subject of double-line symbols for roads, the plan of confining their use to roads fit for wheeled traffic may be mentioned. This has the advantage of being to some extent self-explanatory, which is, however, outweighed by the lack of flexibility and accuracy, referred to above, except in the case of country where roads fit for wheeled traffic are comparatively rare.

The alteration of the cart-track symbol necessitated changes in the representation of camel roads and mule roads, which are now both shown by broken lines, the lengths of the dashes in the former symbol being twice that of those in the latter.

It has been found necessary to draw all roads in rather thicker lines in hilly or broken country than in open country, in order that they may show up clearly.

Indian maps do not show the widths and gradients of roads, except in so far as the latter may be indicated by the contouring. As road traffic becomes more important, owing to the increase in the numbers of motor cars, these items of information will become more valuable. The Italian Military Geographical Institute has led the way in this direction on their new $\frac{1}{100,000}$ map of Italy.

Symbol-tables on the maps.

One question in the design of a new map, that is specially important in the case of a topographical map covering a large number of sheets, is that of the explanation on each sheet of the conventional signs and abbreviations that appear on the map. Modern practice varies in this respect from that of the Swiss $\frac{1}{25,000}$ and $\frac{1}{50,000}$ maps, which show no explanatory table of symbols at all, to that of the new French $\frac{1}{100,000}$ map, which explains over 70 symbols at the foot of each sheet, or of the American $\frac{1}{62,500}$ sheets, on the back of

which all the conventional signs employed, some 70 in number, are printed in grey. The number of symbols to be explained is reduced considerably if explanation is confined to the symbols that occur on the particular sheet, but much labour is saved if the explanatory symbol-tables are standardised and applied to all the sheets of the series: the latter is now the usual practice. If all the symbols used on the different sheets of the map are explained on each sheet, it is necessary either to increase the size of the paper considerably, or to utilise the back of the sheet: both these plans have serious drawbacks.

On Indian one-inch sheets, which number several thousands covering every description of country, symbols that are self-explanatory are omitted from the standardised symbol-tables. These explain some 45 symbols and abbreviations, and any symbol that is not included in the table and is not self-explanatory is specially explained at the foot of the sheet on which it occurs.

Lettering.

The beauty and clearness of a map depend, perhaps more than on any other one factor, on its lettering, and it is probably in this direction that the further improvement of Indian topographical maps may be most confidently expected. The style of lettering adopted is governed, in the first place, by the Indian practice of typing names instead of writing them by hand. While well executed hand-lettering gives the best results, any but the best gives results inferior to good typing. It is difficult to train Indian draftsmen to hand-letter really well, even after they have been subjected to a long course of training, and the very large number of sheets which have to be turned out annually would require a large staff of highly skilled writing draftsmen if hand-lettering were adopted; while any neat draftsman can be trained to type well. The Department has therefore had to choose between the best method giving unequal results, and the second best giving fairly uniform results: the balance of advantage has been considered to incline to the latter.

Opinions differ widely as to the form of type that is most suitable for topographical maps. To begin with, there is the choice between upright and sloping lettering. On Indian maps the difference is used to distinguish the names of administrative centres, which are typed in upright lettering, other place names being in sloping lettering. The distinction is of practical value in India, where it is important to the traveller to know where he can obtain official assistance in the matter of supplies, transport and information; but it is open to question whether it could not be marked equally well in some other manner, *e.g.*, by a symbol. Upright lettering has some practical advantages; it takes up less room, and is perhaps a little more easily read and restful to the eye than italics, or, at any rate, as books are printed in upright lettering, the eye is more accustomed to it. On the recently designed International Map of the World, all place names are in upright lettering, sloping lettering being retained for names of streams and communications. It may, however, be pointed out that the advantages of a compact lettering that takes up little room are more marked as a rule on a geographical than on a topographical map.

Roman *sarif* lettering, with thick lines and hair lines, is generally considered to have more beauty than non-sarif lettering of a uniform thickness, and is almost universally used for place names on engraved maps. The latter is, however, more easily reproduced by photography. Impressions from the ordinary commercial *sarif* type, when photographed, really require a different exposure for the thick lines than for the thin lines, and photographed results, if complete, are apt to be thickened and heavy, or, if kept fine, the sarifs and hair lines are very apt to be broken or to disappear in some places altogether. It is almost impossible with Roman *sarif* type to obtain results that are sharp, clear and complete; these can only be obtained approximately from impressions that are absolutely perfect. It has been suggested that a *sarif* type could be specially cast which would yield impressions that would photograph well, the idea being that the hair lines and sarifs might be made slightly thicker than on ordinary type, so that the same exposure would suit both them and

the thick lines. Arrangements for experiments in this direction have been made with a well-known firm of type founders and it is thought by some experts that they may lead to results which will allow of the use of *sarif* lettering for place names on the topographical maps. It has, however, to be borne in mind that the comparative beauty of such lettering depends to no small extent on the fineness of the *sarifs* and hair lines.

The lettering of the one-inch sheets, other than that of town and village names, calls for few remarks. Open outlined lettering for spaced names has not yet been adopted for the topographical maps, although it is now used on the geographical maps where its advantages are more marked. The names of rivers and streams, which are not of sufficient size to enter in capitals, are distinguished from other small names by being hand-written with a backward slope, a plan of which the advantages are perhaps hardly sufficient to compensate for the difficulty in executing this particular form of lettering artistically.*

Preliminary Editions.

There are two special forms of the modern one-inch maps which should be mentioned here:—Preliminary Editions and Village Boundary Editions. The former (see plate No. XXVII) are prepared from the large-scale plans of districts which have been cadastrally surveyed and which are unlikely to come under topographical survey at an early date after the cadastral survey. As mentioned above, complete information for the preparation of a modern topographical map is not obtainable from Indian cadastral plans, but, in flat cultivated country, the preliminary editions are seriously defective only in information regarding heights and the temporary or permanent nature of water-forms. They were originally published in black only, but are now published in colours pending their supplementary topographical revision and republication as normal one-inch sheets.

Village Boundary Editions.

The old standard sheets showed village boundaries as well as those of major partitions of districts, divisions, provinces and states, and the modern one-inch sheets show the same with the exception of division and village boundaries. The reasons for no longer distinguishing divisional boundaries, are; the confusion likely to be caused by a multiplicity of boundary symbols, and the comparative unimportance, to map users, of the divisions, into which districts are grouped, compared with the districts, which are the units of administration in India.

Village boundaries only occasionally follow natural features or artificial detail, such as roads and the edges of buildings; they are usually marked only at their trijunction corners, and are lines not visible on the ground. The average size of village lands varies; in some parts of the country it is under one square mile, and a map on which their limits are shown is necessarily covered by a reticule of boundary lines which sometimes obscure topographical information and affect its appearance and its usefulness for military purposes. For these reasons, village boundaries are no longer shown on the normal editions of one-inch maps. There is, however, sometimes a demand on the part of civil officers for maps showing these boundaries, and where a local government asks for such maps, special editions of the one-inch sheets, on which the village boundaries are surprinted, are prepared. The one-inch maps are no longer the tactical maps of India; their preparation is, in future, to be confined to the more highly developed tracts of country, while the whole of India is to be mapped on the half-inch scale; there are, therefore, good reasons for making them more especially the civil or administrative map. These considerations and the serious drawbacks in having to prepare special editions of large numbers of sheets may be considered to outweigh the disadvantages of showing village boundaries on the normal editions, if the demand for their entry on the one-inch maps should increase.

Comparison with maps of other countries.

Before leaving the subject of the one-inch map, which has for many years been the normal †primary map of India, a few remarks as to how far it may fairly be compared with the topographical maps of other civilised countries may be appropriate.

* This has been altered since the above was written, these names are now written in upright lettering.

† The term primary map is here used to indicate a map based directly on the field surveys, as distinguished from those compiled or reduced from maps already published; the latter may be termed secondary maps.

In the first place it should be borne in mind that, owing to the area involved, the preparation of a topographical map of India is a more laborious and costly undertaking than the preparation of a topographical map of, say, England, or Italy, or France. To cover the Indian Empire, between 6,000 and 7,000 one-inch sheets are required[1]. For a very large proportion of these sheets there can be practically no demand, such demand as there is, being confined to that of a few officials, who perhaps enter the area of a particular sheet at intervals of several years. The preparation of topographical maps for the whole country is justified, and indeed rendered necessary, by military, administrative, political and scientific reasons, not by the existence of any demand on the part of the public.

Even in areas where there is a comparatively large military, official and mercantile European population, it numbers less than that of an ordinary small town in Europe, and so far there has been no sign of an incipient demand for topographical maps on the part of the Indian population, although it may be expected that this will eventually come. For these reasons, it is clear that a costly method of map reproduction would be sheer extravagance for India at present and the employment of engraving is put out of court for Indian primary mapping. A map that has been produced by any purely photographic process, unless it is drawn on so large a scale and by such highly skilled draftsmen as to render it little cheaper than an engraved map, cannot be fairly compared with an engraving, or even with a map that has been photo-etched in outline and engraved as to lettering.

The modern one-inch Indian sheet was designed as a map to be printed in black, blue, red, green and brown; it has been found possible to elaborate the original design by the addition of yellow and half-tone grey printings, without very seriously increasing the expenditure of the publication offices, but it is doubtful whether further elaboration involving increased expenditure would be justified.

The very large number of small problems which have to be solved in the design of a good topographical map has been hinted at in this sketch of the development of the Indian one-inch sheets. That all these problems have been solved in the best possible way is too much to hope, but it is claimed that the solutions adopted are the results of careful thought and experiment.[2]

Changes in designs.

In the production of a topographical map to consist of thousands of sheets, the survey and mapping of which must extend over several decades, there are two courses open:— the map may be designed once for all and, for the sake of uniformity, the original design retained unaltered until the next cycle of survey and mapping; or continued efforts towards improved methods of depiction and reproduction, greater accuracy and more complete information may be maintained, the aim being the ideal topographical map, within the limits of economy, which, so far, has probably never been obtained. It is this second course which the Survey of India has adopted, and, although only a measure of success can be claimed, progress will, it is hoped, still be made.

Some estimate of the directions in which further changes will develop may be indicated. The lettering, as mentioned above, is not yet as clear and sharp as it should be, and this defect may possibly be diminished by the use of a special type and perhaps also by the exclusion of diffused light in printing from the negative on zinc.[3] More detailed information as to the prevailing forms of vegetation, the seasons of harvest, meteorological conditions, depths of wells, widths of narrow streams, volumes of water supplies, populations of towns and villages[4], the materials of buildings and bridges, widths and

1. As will be explained later, not all of these will be published, as the place of many of them will be taken by ½-inch sheets of ¼ times the area.

2. It is interesting to compare the Indian solutions with those arrived at by the Italian government cartographers in the design of the new $\frac{1}{100,000}$ map of Italy, described by Signor Luigi Gianuitrapani in his brochure "The New Map of Italy, scale 1:100,000" See Survey of India, Departmental Paper, No. 3.

3. The quality of typing has improved a little since the new maps were begun. In addition to the skill of the typer, the description of ink and hand press, and the surface and quality of the paper or board are factors that affect the lettering, and these have each been the subject of experiment and improvement. Rubber off-set printing, it was hoped, would improve the impressions, but, although it does so on inferior printing papers, the results were disappointing in the case of ordinary papers. The introduction of the "Powder" process has, however, considerably improved the reproduction of the lettering, at the same time preserving the finer details of the map from becoming broken.

4. Indication of population by symbols for sites is now being introduced on the $\frac{1}{\text{Million}}$ sheets.

gradients of roads and their suitability for motor traffic may, as the country developes, require to be given by the maps, or by special editions of these; for there is a limit to the amount of special information which can be given, without affecting the clearness and legibility of a map for ordinary purposes.

Half-inch maps.

When the Department was reorganised and the new one-inch maps were designed, in 1905—7, it was intended that the primary map of India should be on the one-inch scale, which was then considered the most suitable for military as well as for general purposes. There are, however, large tracts in India where the natural features are comparatively simple and the works of man practically non-existent, so that all the information the one-inch map was designed to give can be clearly shown in these areas on the half-inch scale, and it has been contested that the one-inch scale is unnecessarily large, and therefore unsuitable for military purposes. The scale of 4 miles to the inch, which was next tried as the tactical scale because it was the next smaller scale on which maps were available, is undoubtedly too small to give sufficient information for tactical purposes.

It has, therefore, been decided that it will be necessary for military purposes to provide a complete half-inch map of India* and that the preparation of the one-inch maps will be confined in future to the more thickly populated and highly developed areas.

The half-inch maps will be exactly like the one-inch maps, in regard to symbols, lettering and colours. The hills will be shown by contours at 100 feet intervals, every fifth contour being thickened; but in the Himalayas and mountainous country generally, where a smaller contour interval will be desirable, the contours will be at 200 feet intervals, every fifth contour being thickened.

Maps on the scale of 4 miles to one inch.

The Atlas of India.

Before the preparation of anything like a complete topographical map of India on a larger scale had been contemplated, that of a quarter-inch map, the Atlas of India, to be engraved in 177 sheets, had been designed and put in hand (see Chapter 1, page 1).

Plate No. XIII shows extracts from four typical Atlas sheets. The Atlas of India and other quarter-inch Indian maps are, generally speaking, secondary maps, that is they have been reduced and compiled from the published primary maps which are prepared directly from the results of field surveys, but the earlier sheets of the Atlas and many of the old quarter-inch sheets of Burma, to which the Atlas does not extend, were primary.

As explained in Chapter I, the Atlas sheets vary in accuracy and fullness of information; but, while they also vary greatly in quality of engraving, their design is fairly uniform, and in lettering, symbols and depiction of hills the last sheets, prepared about 1903, do not differ very greatly from those engraved in the 'forties.

The change in the method of representing town and large village sites, the increased efforts towards showing the character of the surface features by ornamentation, and the greater refinement of engraving in the more modern sheets may be noticed on the specimens, plate No. XIII.

A defect that is not uncommon on the older Atlas sheets is the overcrowding of names; this is probably due to the sheets concerned being the primary maps and the consequent desire to show all the information possible, even at the cost of some loss in clearness.

The preparation and maintenance of the Atlas of India were stopped in 1905, but the sheets are still issued, except where they have been replaced by degree sheets. The plates are in frequent use for the preparation of special extract maps, and where they have been prepared from, or brought up to the date of, the larger scale surveys, or where no larger scale topographical surveys exist, they have still to be used in the compilation of the smaller scale geographical maps.

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* The question of the most suitable scale for the tactical map of any particular country is, however, a somewhat difficult one. Recent experience has shown that, in modern warfare, maps on the scale of $\frac{1}{20,000}$ are necessary for artillery purposes.

Burma quarter-inch sheets.

During the Burmese War of 1885—87 and the years following that of the annexation of Upper Burma, enormous areas were reconnoitered and sketched in Burma, mostly on the quarter-inch scale, and these were mapped in a series of quarter-inch sheets each including 2° of longitude × 1° of latitude.

The sheets were fair drawn and reproduced by photography in the same way as the one-inch sheets of their period; at first in black only (see plate No. XIV), but afterwards in black outline with hills in brown. Like the Indian Atlas the old quarter-inch series of Burma show hills by vertical hachuring.

Degree sheets (old style).

By about 1900, large areas in Burma had been mapped on the one-inch scale and the old quarter-inch series, prepared for the most part from military or geographical reconnaissances, was much out of date. It was therefore decided to prepare, gradually, a new series of quarter-inch maps of Burma, and these were designed as 'degree sheets', each sheet covering an area of 1° of latitude by 1° of longitude. Only a few of these maps were published. They differed from the older quarter-inch maps chiefly in showing hills by brown form-lines, which approximated to contouring, and in increased refinement in drawing and lettering: a fairly typical specimen is given on plate No. XV.

Degree sheets (Transitional).

In accordance with the general reorganisation of Indian cartography described in Chapter I, the preparation from the modern one-inch maps of a complete quarter-inch map of the Indian Empire in degree sheets, to be printed in colours, was decided on. As the area of each degree sheet includes that of 16 one-inch sheets, some time had to elapse before complete material for any of the new degree sheets could be ready, and, in the meantime, a few degree sheets of a transitional nature were prepared from the old surveys. These sheets were to a great extent experimental: while, like the older degree sheets, they could not show contours nor the temporary or permanent nature of water-forms, they differed from them in showing roads and sites in red and in the substitution of half-tone grey shading for form-lines. An extract from a good specimen is given on plate No. XVI.

Degree sheets (Modern).

The modern degree sheet was designed to conform in style and colouring to the modern one-inch sheet, but at first there was no intention that it should be a contoured map. At the time, the employment of contours on any but large scale maps was still a matter of discussion, and the view that prevailed was that the hills on degree sheets should be shown merely by half-tone shading. Further consideration, however, led to this decision being reversed and degree sheets are now contoured.

In accordance with modern practice and the empirical formula stated at page 21, the most suitable vertical interval for contours on the quarter-inch scale is generally considered to be 200 feet, and this interval would naturally follow from those of 50 feet and 100 feet adopted respectively for the one-inch and half-inch scales. The 200 feet interval, however, does not yield a convenient multiple for use where the interval has to be enlarged, in mountainous country, nor does it provide the contours at 250 feet, 500 feet, 1,500 feet, &c., required for the smaller scale geographical maps, which are based on the degree sheets. For these reasons, a vertical interval of 250 feet has been adopted as the normal vertical interval for the quarter-inch scale, with 500 feet as the special vertical interval for use on sheets of mountainous country where the slopes are very steep.

The contouring is supplemented by hill shading executed on practically the same system as that of the one-inch maps, * and by hypsometrical layer colouring.

Hypsometrical Layers.

The reasons for which hypsometrical layering has been rejected for the one-inch map, apply with much less force to the quarter-inch sheets:—a practically uniform scale of layer colouring can be applied to them, the

* As the scale decreases, however, height of feature, as well as the direction of illumination, begins to be a factor affecting the depth of shade; and when very small scales are arrived at, shading becomes merely a symbol denoting the existence of hills, dark strong shading being used for lofty ranges and light shading for low ranges. Also, as on layered maps, the layer colouring increases in strength with height, the shading requires to increase in strength with it, in order that it may show through the layer colour.

additional cost of layer printing is not a very serious matter when it refers to the comparatively small numbers of the degree sheets, and the value of the distinction of wooded and cultivated areas by colour washes decreases with the scale.

The normal editions of degree sheets are contoured, layered and shaded, but there are purposes, more especially in connection with scientific investigations, for which the addition of shading to a layered map is a disadvantage, as it tends to obscure the layering and in itself does not give additional scientific information; also, boundaries cannot well be coloured on layered maps and the position of troops and works cannot be very clearly marked on them in colour. The degree sheets are therefore printed in three editions:—

(*a*) Layered and shaded,

(*b*) Layered without shading,*

(*c*) Shaded without layers.

The first of these forms is probably the one most generally preferred for ordinary use, the second is more useful to geographers and the third for political or administrative purposes. Examples of the first two are given on plates Nos. XVII and XVIII.

The best scale of layer colouring is still a subject of discussion among cartographers (see Chapter VI); that shown on the specimens is the one tentatively adopted after many experiments and, with certain modifications, it is used on all Indian layered maps for the present.

Colours.

It was intended that the colours of the modern quarter-inch map (degree sheets), should be the same as those of the one-inch maps. The quarter-inch map was, however, selected by the military authorities to be the tactical map of India and military requirements had, therefore, to take precedence in its design. This led to the adoption, at the request of the General Staff, of black for town and village sites.† On the subsequent introduction of hypsometrical layering this change would, in any case, have become advisable, because small red sites do not show up well over red or reddish brown layers.

Another difference between the colouring of the one-inch and quarter-inch maps is in the use on the latter of blue lines as the margins of blue water areas (see page 15).

As woods cannot be shown by green washes, owing to the layer colouring, they are indicated on degree sheets by the tree symbols alone; a possible alternative, that of green diagonal rulings, as on the new Italian 1:100,000 map, was considered and rejected. Similarly, cultivation cannot be shown by yellow washes, and its limits, which, if shown, would have to be greatly generalised, are omitted.

The same boundaries are shown on degree sheets as on one-inch maps, but on the first degree sheets prepared, the boundaries of partitions of districts were not shown, although they appear on the old Atlas sheets: it was found that a demand for the entry of these boundaries exists on the part of map users, and they are now entered.

Degree sheets, (Provisional), prepared from Atlas sheets. (Atlas sheet degree sheets).

It will be many years before degree sheets based on the modern surveys in progress can be prepared for even the greater part of India, and, in the meantime, the Atlas of India is the quarter-inch map in existence. There is, however, great inconvenience in using the Atlas sheets, because their margins do not conform to meridians and parallels and, consequently, there is no simple connection in designation and area between them and the other maps of the country: also they are much out of date in regard to communications, &c., so that their revision is, in any case, necessary, and they are now being republished in the form of "Provisional" degree sheets. The best method of doing this is by building up the plates of the provisional degree sheets by means of transfers from the Atlas engraved plates, but as the maps are urgently required, and the staff of zinc draftsmen is very limited,

* Since this was written the publication of the layered edition without shading has been discontinued.

† The reason on which the request was based was that to show a small hamlet site in red gave it too much emphasis and importance.

the more usual method is to cut and paste prints from the Atlas plates for photography, after correcting roads and railways, &c. The results of this method are necessarily inferior in quality of impression to the old Atlas sheets, but otherwise the 'Provisional' degree sheets differ from the Atlas sheets only in size and shape.

Maps on the 8-mile scale.

Before leaving the subject of Indian topographical maps, mention may be made of the different series of maps of South-Eastern Burma and certain frontier areas prepared between 1886 and 1903 on the scale of 8 miles to the inch.

This scale is hardly a topographical one, but it is only maps of the scale of $\frac{1}{\text{Million}}$, or smaller scales, that are officially designated as 'geographical' in India.

The eight mile maps are no longer prepared or maintained. The sheets included 4° longitude by 2° latitude, were based on geographical or military reconnaissances and were rather roughly drawn and printed in black, or in black and brown: they give little if any more information than can be adequately shown on the $\frac{1}{\text{Million}}$ scale by modern methods of mapping.

CHAPTER IV.

DEVELOPMENT OF INDIAN GEOGRAPHICAL MAPS.

Old maps of India.

Plate No. I shows an extract from what is believed to be the earliest printed map of India: it was compiled by Sir Thomas Roe, Ambassador at the court of Akbar, with the assistance of a William Baffin, who is stated to have been the great explorer, and first printed in 1619.

In the latter half of the 18th and the first half of the 19th century, a considerable number of general maps of India were produced; among them may be mentioned one by Monsieur d'Anville, Geographer to the King of France, several by Major James Rennell, the first dated 1788, and others by Mr. John Walker, Engraver to the Court of Directors of the East India Company, and afterwards to the India Office.

One of the earliest of the Survey of India general maps of the country was a map on the scale of 32 miles to 1 inch, "chiefly compiled from Trigonometrical Surveys, and engraved under the orders of the Directors of the East India Company, by Mr. John Walker in 1852". This was followed during the next 30 years by the publication of other official maps of India, on the same and smaller scales, which, although principally compiled from the surveys of the Department, were mostly engraved in London under the orders of the India Office, only the later ones being produced by the Survey of India itself.

The Map of India and Adjacent Countries, scale 32 miles to one inch, 1881.

An engraved map of India on the 32 miles scale, in 6 sheets, was published by the Surveyor General's Office in 1881. It appears to have been intended to engrave hachured hills for it, but, if so, the intention was abandoned and subsequent editions were produced with hills roughly drawn in mezzotint chalk shading on stone. In spite of the poor quality of the hill work, the map was a useful one and passed through four editions, the fourth edition being published as recently as 1908. This fourth edition was intended merely as a stop-gap pending the preparation of a new map. The old engraved plates had become hopelessly out of date, and the very numerous corrections required from time to time had been added on the stones from which the map was printed and had not been cut on the copper. In order to avoid delay, the map was, therefore, revised on the stones, the old chalk hills were touched up and the copies were printed in the political colouring prescribed for maps by the Government of India, under which a distinctive colour is applied to the boundaries in, and of, each province and country, the areas of native states are coloured yellow, those of British India dark red and of tracts under British Administration light red. An extract from the 4th edition of the map is shown on plate No. II.

The Map of India and Adjacent Countries, scale 32 miles to one inch, 1913.

The next 32-mile map of India and Adjacent Countries was compiled *ab initio* from the old topographical maps; it was engraved in 12 plates, and the first, or 'geographical' edition, with hypsometrical layer colouring, was published at the close of 1913.

The compilation from topographical maps of a wall-map covering $40° \times 30°$ of the earth's surface, on so large a scale as 32 miles to one inch, is a work of considerable labour. The need for a new wall-map was urgent, or the proper procedure would have been first to complete the mapping of India on some intermediate scale between the 32-mile scale and the topographical scales. A very small number of the $\frac{1}{\text{Million}}$ sheets had, however, been prepared and all the other then existing maps on geographical scales were based on very old surveys. The only data available for the contours, except in a few isolated areas where modern surveys were in progress,

were the spot-heights on the topographical maps. By interpolating the contours from them a fair approximation to accuracy has been obtained; but in some areas, especially those across the frontiers, information regarding heights was exceedingly scanty, and all that can be claimed for the results is that they interpret such information as was available at the time of compilation.

The design of a suitable system of hypsometrical layering to be applied, on the 32-mile scale, to an area extending from sea level to the summit of Mount Everest and including every variety of topography, presented a problem which could only be solved partially and by compromise. No one scheme of layer intervals and colouring can be devised that will at one time be the best possible for the low curved ridges of Baluchistan, the medium plateaus of the Shan states and the Deccan, the unique table-land of Tibet, the arid basins of Seistan and the loftiest mountain range in the world.

It was evident that, for a wall-map, the layers should be comparatively bold and simple. The following ten land and three bathymetrical layers were adopted as the minimum that would show the general formation of the area:—

Land layers.

0—	500 Feet	6,000—10,000	Feet
500—	1,000 ,,	10,000—15,000	,,
1,000—	2,000 ,,	15,000—20,000	,,
2,000—	3,000 ,,	20,000—25,000	,,
3,000—	6,000 ,,	Above 25,000	,,

Bathymetrical layers.

0—	5,000 Feet
5,000—	10,000 ,,
Below	10,000 ,,

In addition to the contours forming the margins of the layers it was decided to show the contour at 250 feet above sea level and those at 250 feet, 500 feet and at every 1,000 feet interval below sea level. The colour scheme of the layers is approximately that tentatively adopted for Survey of India maps in 1913.

The colouring of the 32-mile layered map has been criticised on the score of the heavy effect of the red mass of colour on the Tibet plateau; this, it is hoped, will be remedied to some extent on the next edition, which it is proposed to print with the areas under perpetual snow left white. There is, however, a practical difficulty in representing the formation of the Himalayas and Tibet by layer colouring and white perpetual snows:— The strongest layer colouring should be the highest,—that just below the perpetual snows; but the snow-line lies at a lower elevation on the south-western slopes of the Himalayas than on their north-eastern slopes and in Tibet, so that while on the south-western slopes of the range the strongest layer colouring will be reduced to a mere ribbon, it must extend over very large areas on the north-eastern slopes and in Tibet. The Tibetan plateau must then tend to be over-emphasised and the main range under-emphasised. This difficulty has not yet been overcome but experiments with a view to its solution have been undertaken.

The design of a wall-map must necessarily differ from that of a field or desk map. If the map is required, in the first place, in order that the physical geography of the whole country may be seen at a glance, boldness in drawing, lettering and layer colouring are essential, and minor details must be omitted or generalised to a greater extent than is necessitated by the scale. An excellent map of this description is the 'Alpen Lander,' scale 1:450,000, by Doctor Hermann Haacke, printed at Gotha. Such a map is, however, intended to be looked at from a distance of over 10 feet, and is unsuitable for other purposes than that of lectures or a general study of the

physical features of a country as a whole, and for the latter object a map on one-quarter the scale would probably be equally useful. The Indian wall-maps, on the other hand, are required for office use, that is, for ordinary reference, their object is not only to convey a general impression of the configuration of the country but also to provide information for the whole of India in a convenient form without reference to a portfolio of many sheets. This necessitates a somewhat refined style of engraving and lettering for all but the most important items of information. When the map of 1913 was designed the Survey of India had had comparatively little experience in the preparation of wall-maps, and some mistakes were made. The outlining, especially the coast-line, and main drainage lines are too finely cut and the more important place names lack emphasis. The names of chief towns of districts are all of the same size, irrespective of the size and importance of the towns; some of them are merely of administrative importance.

A special hair-line lettering has been used for railway station names; the advantage of this distinction hardly compensates for the disadvantage of the introduction of a special form of lettering.

In order to avoid crowding the map with lettering, the names of districts, where they do not differ from those of their chief-towns, are omitted, and, where they do differ, are shown, within brackets, in hair-line capitals. This plan fulfils its purpose and is perhaps the most suitable, but it is open to question whether in view of the great importance of the Indian district as the limit of administration, the names should not be spaced across the districts.

The political edition of the new 32-mile map has not yet been published, pending decisions in the cases of certain boundaries. It will be printed without layers in the political colouring referred to on page 29.*

The map of India and Adjacent Countries, scale 64 miles to one inch, 1883.

A few years after the appearance of the first engraved 32 miles to one inch map, an engraved map of India on the scale of 64 miles to one inch, with hills in fine vertical hachuring, was published at Calcutta. This map has been periodically revised and reprinted, the last time in 1909: it is one of the more successful examples of the old style of Indian engraved cartography. It is now issued in two forms, one in black only and one with political colouring (see plate No. III).

General maps of India on scales smaller than 64 miles to one inch.

Engraved maps of India, on the scales of 48 miles, 80 miles, 96 miles, 128 miles and 256 miles to one inch, were produced in the last quarter of the 19th century and, with the exception of the 48 miles and 96 miles maps, have been periodically revised and are still in use. They will eventually be replaced by maps on similar metrical scales (see page 35).

Maps of provinces, on the scale of 16 miles to one inch.

In addition to the general maps of India mentioned above, a series of engraved geographical maps of provinces, on the scale of 16 miles to one inch, was begun about 1876. This series, which would have been of great value as a link between the small-scale geographical maps and the topographical maps, if it could have been systematically compiled and published, was never completed.

Twelve of the provincial sheets had been engraved by 1903, but, owing to the length of time required for their compilation and engraving, and the continual influx of fresh information necessitating perpetual correction of the plates, the series was not a very satisfactory one, the maps being generally somewhat out of date before publication. An example, from the map of the Punjab, is shown on plate No. VI.

In the same way as the topographical mapping by districts had proved inconvenient, if not unworkable, so it was with the geographical mapping by provinces; it was evident that a system of mapping by sheets bounded by meridians and parallels must be introduced, and that engraving should be postponed until heliozincographed maps had first been prepared.

*This map was eventually published in 1916 followed by a layered and shaded edition in 1917. (See Plate No. IV).

Old style $\frac{1}{\text{Million}}$ sheets.

It was accordingly decided to prepare a series of heliozincographed sheets on the scale of $\frac{1}{1 \text{ Million}}$, or 16 miles to 1·014 inch, each sheet to include 4° of latitude by 4° of longitude, and to abandon the preparation of engraved maps of provinces.

An extract from one of the first sheets published, showing the original design of the Indian $\frac{1}{\text{Million}}$ map, is given on plate No. VII.

The hills, like those on most geographical maps of their period, were shown by vertical hachuring, a method which, though capable of rendering the forms of the hill features very successfully, fails to give much effect of relative relief between them. Like the old style topographical maps, the old style $\frac{1}{\text{Million}}$ sheets were printed in black with hills in brown, a separate drawing being prepared for each colour. An attempt was made on them to revive the half-forgotten art of hand lettering, but it was only partly successful and was not continued.

Modern $\frac{1}{\text{Million}}$ sheets. India and Adjacent Countries, scale 1:1,000,000.

When a comprehensive sheet framework for Indian cartography was introduced in 1906, the $\frac{1}{\text{Million}}$ series of sheets was adopted as the basis of the system. The sheet framework of the series was extended to cover the greater part of Asia, the sheets were numbered consecutively from the north-west and the series was entitled "India and Adjacent Countries." Each sheet, including 4° × 4°, was divided, as explained in Chapter I, into 16 quarter-inch degree sheets (1° × 1°), which were, in their turn, each divided into 16 one-inch sheets, ($\frac{1}{4}$° × $\frac{1}{4}$°). Just as the degree sheet was to be prepared from reductions of its 16 component one-inch sheets, so the $\frac{1}{\text{Million}}$ sheet was to be prepared from reductions of its 16 component degree sheets. While, however, owing to the existence of the Atlas of India, which provided a quarter-inch map of the country for use in the mean time, it was not absolutely necessary to prepare a degree sheet until its component one-inch sheets had been surveyed and mapped, it was impossible to await the preparation of modern degree sheets before beginning that of the $\frac{1}{\text{Million}}$ sheets, because there were no geographical maps on a scale intermediate between those of the general 32-mile map of India and of the topographical maps, with the exception of the few out-of-date provincial maps on the 16 miles scale.

The preparation of the $\frac{1}{\text{Million}}$ sheets from the old topographical maps, corrected so far as information was available, was proceeded with, and, in keeping with the improved cartography of the modern topographical maps, the design was modernised, and the new style of colouring and the new topographical conventional signs were adapted to the geographical scale.

Roads and sites were to be in red; water-forms, temporary and permanent, and their lettering in blue; railways and the mass of the lettering in black, and the hills were to be shown by grey half-tone shading. A specimen of this style of $\frac{1}{\text{Million}}$ sheet, which may be termed transitional, is given on plate No. VIII.

Half-tone hill shading was a comparatively new process in the Department, and it was soon found that, used by itself, it is a very inadequate method of representing the features of the ground. On a geographical scale, shading cannot give much scientific information and amounts to little more than a symbol for hilly ground.

The system of hypsometrical layer colouring had just recently been introduced in India in the design of the new $\frac{1}{2 \text{ Million}}$ sheets, and the Surveyor General decided that it was necessary that the $\frac{1}{\text{Million}}$ map should be contoured and layered.

In the absence of contoured topographical maps, there was considerable doubt, at first, whether data for the contours were available. The task was, however, undertaken and it was found that there were sufficient numbers of spot-heights on the old topographical maps from which, with the

assistance of the form-lines or hachuring, contours could be interpolated with an approximate accuracy which was sufficient when the contouring was reduced to the $\frac{1}{\text{Million}}$ scale. A uniform contour interval could not be adopted because, in the higher areas, the available information was very scanty; nor, indeed, had more information been available, would the laborious contouring of very lofty regions at a close interval proved of much practical value. The 250 feet contour above sea level is required, as it helps to define the low alluvial valleys which are such important features in a map of India. From 500 feet to 4,000 feet above sea level the contour interval is 500 feet, it is then 1,000 feet up to 6,000 feet above sea level, and 2,000 feet from that height to 10,000 feet above sea level; above 10,000 feet the interval is uniformly 2,500 feet.

These intervals were selected partly in order that the contours should correspond closely with the metrical contours of the International Map of the World.

The addition of layer colouring brought about a change in the colour of sites, which had now to be in black, and at the same time a few minor alterations in the lettering were introduced, *e.g.*, the adoption of a double-line open lettering for district names.

As in the case of the degree sheets, it was found that more than one form of the $\frac{1}{\text{Million}}$ map is required and the sheets are now published in three* editions;—with contours, shade and layers; with contours and layers; with contours and shade; the last form having coloured boundary ribbons. Plate No. IX shows an extract from one of the heliozincographed sheets, with layers and shading.

A few of the more important $\frac{1}{\text{Million}}$ sheets are engraved: an extract from an engraved sheet with layers is shown on plate No. XIA.

La Carte Internationale du Monde au 1,000,000e.

Towards the close of the 19th century, there had arisen among geographers a movement in favour of the preparation of an International Map of the World on one scale, in a uniform style. The proposal was mooted by Doctor A. Penck at the Fifth International Geographical Congress, held at Berne in 1891, and was discussed again at later congresses. Eventually, an international committee of cartographers and geographers, which was assembled in London in 1909 under the auspices of the British Government, definitely decided that a map of the world, on the scale of $\frac{1}{\text{Million}}$, should be produced, and that the respective governments should prepare and publish the sheets of the map in which their territories were included, in accordance with certain rules and specifications which the committee promulgated. The Survey of India was ready to take its share in the task, but it had already designed and begun its own $\frac{1}{\text{Million}}$ map which differed from the International Map in two very important particulars; size of sheet and unit of height measurement. The 'International' sheets each include 6° of longitude by 4° of latitude, while the Indian sheets include 4° of longitude by 4° of latitude, and could not be altered in size without upsetting the whole Indian cartographical framework; also, the time has not yet come when height can be shown in metres on maps to be used in India. It is therefore necessary for the Survey of India to prepare two separate series of $\frac{1}{\text{Million}}$ sheets:—their own, and the 'International.' The Indian sheets of the latter series will all be engraved and are undertaken after the corresponding sheets of the Indian series have been published. The original design of the International Map was altered in some respects, notably in its scheme of layer colouring, by the second sitting of the international committee in Paris in 1913. The extract from sheet North 43.-E, shown on plate No. XI, is in accordance with the original specifications as regards outline, the engraving having been begun before 1913, and with those of 1913 as regards layer colouring.

By taking part in this international task the Survey of India gains indirectly, even although the 'International' sheets are unlikely to be used much in India; the work helps the Department to continue in close touch with modern cartographical development and it is hoped that something may be learned

* Since the above was written the publication of the edition with contours and layers but no shade has been discontinued.

from the preparation of two series of maps in different styles of the same areas. Apart from the size of sheet and the unit of height measurement, a few of the chief points of difference between the maps are :—

The lettering of the 'International' map is uniformly upright with the exception of that of water-form and communication names, while on the Indian map all the less important place names are in italics.

The contours are, by the specifications of 1913, to be fine black dotted lines* on the International Map; on the Indian map they are brown continuous lines. The classification of site symbols is much more elaborate on the 'World' map than on the Indian map, and the former is to show trees in plan by small black irregular circles† while the latter does not show them at all.

The preparation of the International Map has already begun to react on that of the Indian series of $\frac{1}{\text{Million}}$ sheets. The first system of layer colouring adopted for the latter was based on the specification of the international committee (see Chapter VI), also, in order to classify the sites of towns and villages on the international sheets, the classification based on population, which was formerly marked by the size and style of lettering on the Indian series, is now being applied to the symbols for sites on both series.

The $\frac{1}{2\text{ Million}}$ sheets. Southern Asia Series.

The reorganisation of 1905—08 had made no provision for any series of sheets on scales smaller than $\frac{1}{\text{Million}}$. The experience acquired in the preparation of the 32-mile map had, however, shown the practical difficulty of preparing a map of the whole of India in one operation, to include all the latest information available at any one time that could appear on the 32-mile scale. Also, the plan of preparing separate special maps of countries like Persia and Afghanistan had been found very inconvenient; such maps overlap, involving reduplication of work, and are exceedingly difficult to bring up to any particular date owing to the large areas they include; moreover, the introduction of an international map on a metrical scale, and the general tendency towards the adoption of metrical scales for new maps in other countries, rendered such scales advisable for any new Indian maps that might be required.

For these reasons, it was decided in 1909 to institute a series of $\frac{1}{2\text{ Million}}$ sheets, to cover the whole of Southern Asia and to be termed the 'Southern Asia Series.'

The design of the new maps was marked by two new departures in Indian cartography;— the size of the sheets of all other modern Indian series is uniform, that of $1^\circ \times 1^\circ$ on the quarter-inch scale; but for a desk or wall-map a larger size of sheet has distinct advantages. Instead, therefore, of including 4 sheets of the $\frac{1}{\text{Million}}$ series and covering an area of $8^\circ \times 8^\circ$, the new $\frac{1}{2\text{ Million}}$ sheet was made to include 6 sheets of the $\frac{1}{\text{Million}}$ series and to cover an area of 12° of longitude by 8° of latitude.

The other departure was the adoption of hypsometrical layer colouring, the method of orography that was becoming recognised as undoubtedly the best and most scientific for small scale mapping.

The introduction of the $\frac{1}{3\text{ Million}}$ map has simplified the arrangement of the programme of Indian small scale mapping. The $\frac{1}{2\text{ Million}}$ sheets of India are prepared from the $\frac{1}{\text{Million}}$ sheets, a sheet being put in hand when the publication of its component batch of six $\frac{1}{\text{Million}}$ sheets is completed, and from the $\frac{1}{2\text{ Million}}$ sheets a new engraved wall-map of India and Adjacent Countries on the $\frac{1}{2\text{ Million}}$ scale will eventually be prepared.

In 1909 the Indian $\frac{1}{\text{Million}}$ mapping had not, however, made sufficient progress to warrant the commencement of the $\frac{1}{3\text{ Million}}$ mapping of India itself, while a new map of Persia, to be compiled from the latest information, was urgently required. The first sheets of the new series to be published were,

* It is possible that this may be found to interfere with the lettering.

† They will require to be carefully engraved to distinguish them from small sites.

therefore, those which included parts of Persia, namely, the four sheets—Southern Persia, Northern Persia, Afghanistan and Baluchistan. These sheets, when pasted together, provide a convenient map of Persia which has fully warranted the adoption of the sheet system as opposed to the special area system of small scale mapping for Survey of India purposes. An extract from 'Southern Persia', the first sheet of the series to be printed, is shown on plate No. V.

The sheets of the Southern Asia Series, scale $\frac{1}{2\text{ Million}}$, are prepared and reproduced by photography in the same way as those of the India and Adjacent Countries series, scale $\frac{1}{\text{Million}}$. The contours and layer intervals are nearly the same as those of the 32-mile map, from which they differ by showing 4 additional layers at 1,500, 4,000, 5,000 and 8,000 feet above sea level. The additional layers were originally found to be necessary on the Persian sheets, in order to represent properly the basins, table-lands and lower ranges of Persia, and they are also being entered on the Indian sheets under preparation. The greater elaboration of the layering as compared with that of the 32-mile map, which is on practically the same scale, is also in accordance with the principle that a wall-map requires simpler and bolder treatment than a desk map, if it is to fulfil its double object of providing a generalised view of the country in addition to sufficient detailed information for ordinary references. The $\frac{1}{2\text{ Million}}$ sheets are useful for the formation of maps of provinces and of countries such as Persia and Afghanistan, but they cannot be expected to produce a really satisfactory wall-map of the Indian Empire merely by pasting the sheets together: the inherent differences between maps for desk and wall use preclude this.

Preparation of a wall-map of India and Adjacent Countries from the $\frac{1}{2\text{ Million}}$ sheets Map of India and Adjacent Countries, scale $\frac{1}{4\text{ Million}}$

When the modern programme of small scale mapping by sheets has made sufficient progress, a new engraved wall-map of India and Adjacent Countries, on the $\frac{1}{2\text{ Million}}$ scale, will be produced to supersede the 32-mile map, and from it new wall-maps of the same area, on the $\frac{1}{4\text{ Million}}$ and $\frac{1}{8\text{ Million}}$ scales, will eventually be derived. A layered map of India on a smaller scale than 32 miles to the inch is, however, required in the mean time, and a new map on the $\frac{1}{4\text{ Million}}$ scale, in 4 sheets, is being compiled, directly from the $\frac{1}{\text{Million}}$ sheets and other sources of information, and will be engraved as a stop-gap pending the systematic production of a map on that scale from the $\frac{1}{2\text{ Million}}$ wall-map, which is to be derived from the $\frac{1}{2\text{ Million}}$ sheets, which, in their turn, are being prepared from the modern $\frac{1}{\text{Million}}$ sheets.

New provincial maps.

There is a frequent demand for special maps of Indian provinces and, to meet it, a new series of provincial maps will gradually be produced in the form of extracts from the 32-mile map of 1916: the publication of this series has recently begun with the map of Bengal.

CHAPTER V.

MAPS FOR SPECIAL PURPOSES.

Special maps prepared by surprinting additional information on Departmental maps.

In addition to the maps of its regular series, the Survey of India prepares large numbers of special maps. Perhaps the most numerous class of these consists of maps prepared by surprinting special information on to the ordinary departmental sheets, or extracts from them.* Examples are,— maps to illustrate new railway or canal projects, or the travels of a scientist, maps to show the prevalence of different diseases in certain areas, geological maps, botanical maps, ethnographical maps, trade return maps, &c. The maps of this class are usually of merely temporary or technical interest and are not stocked and issued to the public.

Maps to illustrate the working of Government departments.

A more important class are maps, such as the different varieties of Railway maps, Postal and Telegraph maps, Census maps, &c., which are prepared to illustrate the working of some government department. As a rule, copies of such map are stocked and issued to the public. Among these are the Railway, Canal and Road Map of India, scale 32 miles to 1 inch, and the Railway Administration Map, scale 64 miles to 1 inch. The former is based on the engraved 32-mile map of India and Adjacent Countries, fourth edition; it is to be republished at intervals of several years and is in 2 forms, one of which shows rainfall contours in addition to the information indicated by the title. The Railway Administration Map is a heliozincographed map showing in different colours all existing railways and those under construction, their gauges and, except in the case of 2′ and 2′-6″ lines, whether the lines are double or single. It is brought up to date, from information supplied by the Railway Board, and published annually together with a special form showing projected railways in addition to the others. The Railway Station Map, scale 32 miles to 1 inch, showing every railway station, and the Telegraph Map, a somewhat similar publication, may also be mentioned. Although they can hardly be considered as maps in the ordinary sense of the word, meteorological charts may be mentioned under this head. Some 750,000 charts per annum for daily weather reports for the east, south and west of India and for the country as a whole are supplied to the different Meteorological Offices, in addition to the supply of charts for monthly and annual weather reviews and for monsoon reports. The weather charts are small-scale skeleton maps printed in blue, or in blue and red, with reference tables and notes, and are used as bases on which the Meteorological Department surprints the information of its reports in symbols and figures.

ecial maps of rticular areas.

A third class consists of maps of particular areas of administrative or military importance. These are usually made up from the sheets of the ordinary Departmental series, and, if of permanent interest, are stocked and issued to the public. Among those that have been compiled separately may be mentioned a special series of skeleton maps of districts originally prepared for the illustration of administrative reports by district officials. They are mostly engraved in outline to show merely the most important rivers, towns, communications and the limits of sub-divisions of districts, and are each in one sheet on scales of 16 miles, 12 miles or 8 miles to the inch. The District Administrative Report Maps began to appear in 1886 and about 170 had been published when, on the reorganisation of the Department, their preparation was stopped in accordance with the principle that the preparation of special maps should, as far as possible, be avoided and that officials should be encouraged to use the ordinary series of sheets. In 1874 the publication of a special

* Advice regarding the preparation of maps, diagrams, &c., to illustrate official reports and as to the processes most suitable under different circumstances is published by the Photo.-Litho. Office, Calcutta, in a hand-book entitled "The Reproduction of Maps, Plans, Photographs, Diagrams and Line Illustrations".

series of topographical district maps, on the scale of 4 miles to the inch, was begun; 126 of these maps are maintained but the series is far from complete. There exists, however, a constant though small and scattered demand for district maps and, when the country has been provided with new series of $\frac{1}{4}$-inch and smaller scale normal sheets (or at an earlier date, should establishment be available for the work), it will probably be advisable to bring out a complete series of district maps on the $\frac{1}{4}$-inch scale as an ordinary Departmental series, just as it has recently been found necessary to produce a regular series of provincial maps on the scale of 32 miles to the inch.

Special sheets of country round cantonments.

When the modern one-inch sheets of the neighbourhood of a large cantonment have been published, a special sheet to show the cantonment and neighbourhood covering an area of 20 miles × 20 miles is produced.

Manœuvre maps.

Several special maps of manœuvre areas have been prepared at the request of the General Staff. These are, as a rule, merely extracts made up from the sheets of regular series.

Maps prepared from special surveys for fiscal or technical purposes. Fiscal maps.

Under this head may be classed the most important and best known of the maps for special purposes. The old 4-inch revenue surveys and their successors the cadastral surveys have already been briefly described, in Chapter III, in connection with the preparation of the one-inch sheets, and specimens of their maps are given on plates Nos. XXXII and XXXIII.

Forest Maps.

The Indian Forest Department requires special maps of reserved forest areas, for administrative and technical purposes, to show, in addition to the ordinary topographical information, such special items as forest boundary pillars, fire lines and the boundaries, numbers and designations of the blocks into which reserved forests are partitioned. These have been provided under several different arrangements in the past. At one time the 'Forest' survey and mapping were executed by special parties of the Survey of India; later on, the work was done by the Forest Department itself, officers and a proportion of trained surveyors being lent by the Survey of India for the purpose. Since 1906, the 'Forest' surveys have been carried out by the topographical parties, as part of their normal work, and the mapping is done by a special drawing office at Dehra Dun and printed by the reproducing office at that place.

The normal scale of survey and mapping for 'Forest' purposes has been 4 inches to the mile, but 'Forest' maps are now prepared, either on the 2-inch scale, by adding certain information of technical importance to enlargements of the fair sheets of the one-inch map which are on the $1\frac{1}{2}$-inch scale, or on the 4-inch scale, from surveys of particularly important forests, specially made on that scale as part of the topographical programme of survey.

An extract from one of the old style 4-inch 'Forest' maps is shown on plate No. XXXIV.

Town maps and plans.

Formerly it was the practice for the survey of all important towns, falling within the area allotted to a topographical survey party, to be made on the 6-inch or 12-inch scale. Although this practice has been abandoned for many years, the old maps on these scales of a large number of towns are still stocked and issued.

At the time when most of the old town surveys were made, general maps of the towns, on scales of 6 or 12 inches to 1 mile, were all that were required for government or municipal administration, but, in recent years, a demand for large scale plans, showing dimensions as small as a few feet has arisen. In India, these more elaborate maps are now termed town plans and the general maps of towns on the medium scales, such as the 6-inch or 12-inch scale, are termed town maps.

The survey of towns and the preparation of town plans are not now part of the normal duties of the Survey of India, but are usually carried out by the municipality concerned, with the aid of some retired officer of the Department, except where, as in Bengal, there is a special survey department forming a branch of the local administration that can undertake the work. The former system is not always entirely satisfactory and it is possible that the preparation of certain town plans may, in the future, be

allotted to the Survey of India and that the old custom of surveying and mapping important towns on the 6-inch or 12-inch scales may be resumed. In the case of the important large scale survey of Bombay, now in progress, an accurate traverse framework has been made by the Survey of India and the services of an officer to hold charge of the survey have been lent to the municipality.

An extract from the engraved 6-inch map of Calcutta, based on surveys carried out by local agency is given on plate No. XXXVI.

Cantonment maps.

Plate No. XXXV shows an extract from one of the cantonment maps. The surveys of cantonments, which are made chiefly to meet the requirements of the Military Works and Cantonment Magistrates departments, are now a recognised duty of the Survey of India. The scale of survey and publication has usually been 16 inches to one mile, the same as that of the cadastral surveys, but the "bazars" of many cantonments have been specially surveyed and mapped on larger scales, *e.g.*, 48 and 64 inches to one mile. A special survey party is employed in making new cantonment surveys and maps.

Motoring road maps.

The preparation of special road maps, to meet the increasing demands for such maps on the part of touring officials and the motoring public, has been considered, but it has been thought advisable to leave this work to private enterprise. Road maps of more than one province have already been produced in this way and the organisation of the Survey of India, unless it were expanded specially for the purpose, would not allow of the acquirement and record of special information regarding roads in areas other than those which may happen to be under survey.

Aviation maps.

Experiments in the preparation of aviation maps, on the lines of the sheets of the French 'Carte Aéronautique', have been carried out, and special enlargements of certain of the ordinary maps have recently been made and issued, at the instance of the General Staff, for the use of aviators on active service; but the necessity for special maps for aviation purposes has not yet been clearly established, and the results of experience gained in war will be awaited before anything further is done in this direction.*

Triangulation and levelling charts.

A branch of geographical work that is closely connected with Indian mapping is the preparation of triangulation charts and levelling charts, which has recently been reorganised to yield, eventually, a complete and easily accessible record of the scientific framework on which Indian cartography is based. The charts, specimens of which are shown on plates Nos. XXXVII and XXXVIII, are prepared under the supervision of the Superintendent of the Trigonometrical Survey at Debra Dun, where the more purely scientific work of the Survey of India is concentrated.†

Expected increase of cartographical work in the future.

It is probable that by the time the whole of India has been surveyed and mapped in the regular series of sheets on the five normal scales, surveys and maps on larger scales will be in demand and the number and importance of the special maps required for administrative, political, military and scientific purposes will have increased enormously. Cartography, which for the first 140 years' existence of the Survey of India, was the neglected step-child of the Department, will then assume an importance similar to that it has attained in other national surveys. The increase in output of maps, and, therefore, in the general usefulness of the Department, is already marked, and, although the demand for maps throughout the Indian Empire is still in its infancy, the numbers of maps sold to the public and issued to officials are rising each year and there are signs that a general interest in maps is gradually spreading in the country.

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* Since the above was written the General Staff have laid down rules for the preparation of Artillery and Aviation Maps.

† Complete accounts of the Department's geodetical achievements are published, mainly in the following series of volumes:—"Account of the operations of the Great Trigonometrical Survey of India," (15 Volumes, 1870—93); "Synopsis of the results of the Operations of the Great Trigonometrical Survey of India, comprising descriptions, co-ordinates, &c., of the Principal and Secondary Stations and other fixed points of the several series of Triangles," (34 Volumes, 1874—1894); and "Spirit Levelling Operations of the Great Trigonometrical Survey of India," (26 Volumes, 1858—1895).

CHAPTER VI.

INTRODUCTION OF HYPSOMETRICAL LAYERING.*

First experiment

The first attempt by the Survey of India at producing a map in layers of colour to show zones of altitude was made in 1909, when a special map of "Simla and Adjacent Country," on the 1-inch scale, was prepared. See plate No. XXXIX.

At that time, layers had become popularised by Mr. Bartholomew's beautiful series of topographical maps prepared from Ordnance Survey sheets, the Ordnance Survey had recently introduced the method on its half-inch maps, and other national survey departments had also begun to take up the question of improvements in hill representation.

Monochrome layering.

The Simla map was layered all in brown, a plan which is sometimes preferred to layering in different colours because, among other reasons, it can be made to combine some of the advantages of shading with those of layers. The monochrome system has, however, the disadvantage of being inapplicable to maps on which a large number of layers have to be shown; 8, or possibly 9, different shades of one colour being the most that can be obtained satisfactorily in printing; it is, therefore, inapplicable to a series of sheets covering a great extent of country, if the sheets are to join up.

In 1909, the Photo.-Litho. Office was unprovided with stipple or ruled plates of sufficient size for colour printing maps, and had had little experience in printing varying gradations of colour. The Simla map was, therefore, printed in successive solid printings, a method quite unsuitable for ordinary map printing. The results were very fair; the map is a popular one and fulfils its purpose of providing touring officers and visitors to Simla with a special one-inch map showing in marked relief the surrounding hills and valleys.

Layers on the $\frac{1}{2\ Million}$ sheets

Early in 1911, when the new series of sheets of Southern Asia, on the scale of $\frac{1}{2\ Million}$, was designed, it was decided to make it a layered series and the preparation of large engraved plates of different rulings for colour printing was put in hand. The specification for the layers of the International Map of the World had, in the mean time, been received, and, although the new $\frac{1}{2\ Million}$ map was to show fewer layers than the International $\frac{1}{Million}$ map, the latter's system of layer colouring, from greens through yellows and browns to magenta receding to white at the highest zone, was, with certain slight modifications, adopted tentatively for the $\frac{1}{2\ Million}$ maps.

Decision to layer all geographical maps and degree sheets.

In 1911, owing to the defective representation of hills on the old style $\frac{1}{Million}$ sheets, which were not contoured, the Surveyor General investigated the general question of hill representation on maps and came to the decision that all the geographical series of Indian maps should, in future, be layered. In connection with this investigation, experimental copies of degree sheet 38 N with the hilly areas layered in brown and the plains areas left white were prepared; the results were not satisfactory, so copies were also produced with the whole sheet layered in the modified scheme of colouring of the International Map which was then being applied to the $\frac{1}{2\ Million}$ sheet of Southern Persia. These were very successful, the sheet was printed with the same

* See also Appendix II.

layers, both with and without the addition of shading and it was decided to continue to layer degree sheets in the same manner pending the acquirement of further experience.

ilure of the ternational eme of layer 'ouring when lied to South- ern Persia.

Soon after this, the first proofs of 'Southern Persia', scale $\frac{1}{2 \text{ Million}}$, appeared, but the modified international scheme of colouring, which had proved so successful on 38 N, [the heights on which did not rise above the first magenta layer], was found unsatisfactory on the $\frac{1}{2 \text{ Million}}$ sheet.* The map was printed in two editions, one with the modified international colouring, without shade, and the other with shade and with bright red top layers, as recommended, on the principle of spectrum colouring, by Dr. Karl Pencker.† See plate No. V. Copies of both editions were circulated for criticism among map experts and geographers. A number of valuable criticisms were received and although several recommended modifications in the tone and strength of colours, *e.g.*, stronger blues in sea layers, darker and less yellow greens and lighter browns, nearly all the opinions were in favour of the general scheme of colouring and more especially of the bright red top layers with shading.

ıyers on the $\frac{1}{\text{Million}}$ sheets.

The first $\frac{1}{\text{Million}}$ sheet to be contoured was No. 53. It includes a range of altitude from 250 feet to over 25,000 feet above sea level and was, therefore, peculiarly suitable for experiment, as it would show the complete scale of layer colouring.

There was some doubt at first, whether, even if a large number of layers was employed, and a uniform scale of colours could be adopted, that would give good results on all the sheets of the series, but Captain M. O'C. Tandy, R.E., who was asked to investigate the range of altitude in each sheet was able to show that a uniform scale could be made applicable to all Indian sheets.‡

Previous experience with degree sheet 38 N and the $\frac{1}{2 \text{ Million}}$ sheet 'Southern Persia' was not considered quite conclusive, and it was still thought possible that the top layers might be made to recede in strength in zones, as prescribed for the International Map of the World. Sheet No. 53, scale $\frac{1}{\text{Million}}$, was, accordingly, proved on the international system of colouring, but the results gave a most misleading impression of the ground; the lofty plateau of Tibet and the still higher ranges of the Himalayas appeared to be lower than the stronger zones of red brown below them. The system of recession in strength of colour at the highest layers was, therefore, definitely abandoned. Fifty copies of the map with international layering were, however, printed and sent to the War Office for the consideration of the conference which was to consider questions in connection with the International Map at Paris in 1913.

Sheet 53 was next proved in what may be termed the Survey of India layer colouring; the lower layers were still based on the international scale, but the greens were strengthened and the browns taken rather higher up the scale, while the top layers were made a bright carmine. The results were considered satisfactory and the sheet was printed. Copies were circulated, with and without shading, as in the case of the $\frac{1}{2 \text{ Million}}$ sheet, and met with approval generally, although some experts considered the brown and red layers were too strongly printed. An experiment with the same sheet, showing the top layers in gradually darkening browns, mixed with dark purple in the highest zones, was tried, but the results, although successful in bringing out in relief the form of the earth's surface, were not superior to the sheet as printed with red top layers, and the dark browns tended to obscure lettering. The Surveyor General, accordingly, directed the tentative adoption of the general scheme of layer colouring used on sheet 53 for all layered maps. It was, however, recognized that the problems of layer colouring were still at the experimental stage, and it was hoped that the colour scale could be improved.

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* This was especially marked on the shaded copies: the combination of shade which was strongest in the high ranges and of layer colouring, which receded in strength with altitude, was unfortunate in results.

† Höhenschichtenkarten, Studien and Kritiken Zur Lösung Des Flugkartenproblems, (Konrad Wittwer, Stuttgart 1910).

‡ "A Consideration of the contour intervals and colour scales best suited to Indian $\frac{1}{\text{Million}}$ Maps", printed departmentally, Calcutta, 1913.

As red roads showed up badly in red layers, the substitution of black for red roads on layered maps was considered and tried, but was abandoned for other drawbacks: the defect is not of much importance owing to the paucity of roads at very high altitudes.

Another difficulty was the representation of glaciers; when they were left white, they were too prominent, and, after experimenting, it was decided to show them on layered maps by a combination of the layer colouring with a blue tint, their limits and form-lines being shown in blue. This method has since been abandoned owing to the adoption of white for all areas on layered maps, permanently covered by snow and ice.

Layers on the 32-mile map.

The tentatively adopted scale of colouring was next applied to the 32-mile map of India and Adjacent Countries. (See plate No. V). After some consideration, it was decided that 9 was the smallest number of land layers that would show the morphology of the country at all adequately, and, as the map is a wall map, (7 feet × 7 feet), intended, not only for detailed reference, but also to be viewed as a whole at a distance of 10 feet or more, the omission of a number of the colour gradations of the scale was considered an advantage. The map is in 12 sheets and some difficulty was experienced in matching the colouring on all the sheets when printing them. Experiments had to be carried out on single sheets and it was not easy to judge the effect of modifications in colour, when applied to the whole map. On the whole, the results were fairly successful; they have been criticised on the ground that the rather bluish green of the bottom layer does not stand out sufficiently from the blue of the first sea layer, and that a warmer tone of yellow and of the lightest brown and a weakening of the top red layers would be improvements.

Adoption of white for regions of perpetual snow and ice.

The plan of leaving the top layers white over regions of perpetual snow and ice has obvious advantages; it was deliberately rejected in the case of the first Indian layered maps because it is based on a different principle from layering, the snow line not following a contour; although it was partially aimed at by the International Map specifications, on which the Indian layering was first based, in that on the International Map the top layer above 7,000 metres was to be left white. The plan was tried experimentally on sheet No. 53, in 1913, and, when combined with light half-tone shading, was found very successful; it has recently been adopted for Indian geographical layered maps to be prepared in future.

Revision of the 32-mile layered map.

A revised edition of the 32-mile map is now in hand; a series of experiments, showing more transparent colouring and toned down reds, was first carried out and the results carefully considered. It has, however, been decided that although the strong red of the Tibet plateau on the first edition may not be considered artistic, it emphasises and displays the unique morphology of the region, and that the comparatively strong browns and yellows of the medium layers show up the higher hills of the Peninsula and the Khasia and Burma surveys, which would have insufficient emphasis in the rather more transparent colours of the experiments. The changes in colour will, therefore, probably be limited to slightly strengthening the blue layers, adding a blue line round the coast, emphasising the blue of rivers,* darkening the green of the lowest land layer and leaving the regions of perpetual snow and ice white.†

Revised layering of the International Maps.

At the Paris meeting in the autumn of 1913, the international committee introduced several modifications in the scale of layer colouring. The white, which formerly indicated areas of over 7,000 metres altitude, is now to be used to represent areas of perpetual snow and ice. The magenta of the layers just below the white on the old scale is replaced by carmine on the new scale which gains in strength with height instead of weakening as the magenta layers did. The greens at the foot of the scale have been made bluer. The international scale now differs very little from that tentatively adopted for the Indian maps but the browns and reds are a little less strong and more transparent.

* The rivers and coast-line have been engraved rather too finely for a wall map, see page 34.

† The revised edition of the 32-mile layered map was published eventually in 1917: an extract from it is given on Plate No. IV.

ural systems of layer colouring.

Attempts have been made to introduce some natural system of layer colouring based on scientific principles. The best known and most successful is Doctor Karl Pencker's system of the spectrum. Doctor Pencker maintained that the colours at the red end of the spectrum have a naturally prominent character and stand out, giving the effect of nearness, while those at the violet end have a recessive character and give the effect of remoteness. There is undoubtedly much truth in these statements and the red top layers adopted by the International Map Committee and the Survey of India are a tribute to them.

A map layered rigorously on the principle of the spectrum has violet coasts and lowlands; blue is too naturally and firmly established as the colour for the sea to be changed lightly, the effect of blue and violet over layer sea areas and coastal plains respectively would probably be unpleasing until the eye were trained to it, and the land on such a map would not stand out very prominently from the sea. These are not very serious drawbacks: the spectrum layer system is undoubtedly a good one and will probably influence future cartography in an increasing degree. The specimen map given in Doctor Pencker's pamphlet is very effective.

Another suggestion has been that the gradual reduction of temperature with altitude should be exemplified by using cool colours for high layers and warmer colours for low layers, the exact opposite of Doctor Pencker's system. The question of layering becomes akin to that of shading, if lightness and heaviness of colour are employed to indicate height and depth, or, as is more usual in the case of maps, if strength of colour increases regularly through the layers with height, as in the all brown or monochrome method of layering. The problem of the layer scale, like many other problems in map making, would be greatly simplified if each sheet of a map could be treated individually on its own merits.

Even with so large a range of colouring as that of the International Map, and on so comparatively small a scale as the $\frac{1}{\text{Million}}$ scale, some sheets are bound to suffer owing to the small ranges of altitude they include, if a uniform system of layer colouring is applied to a large series of sheets, *e.g.*, sheet "South H. 34, Kenhardt". This is still more marked in the case of the larger scales, and a uniform system of layers on the quarter-inch scale in a country like India, with its great expanses of featureless plains, has to be confined to sheets which include some hilly country. Indian degree sheets that include only plains areas are neither contoured nor layered.

In their main scheme of colouring the layer scales of Mr. Bartholomew's maps, the Ordnance Survey ½-inch maps, the International Map and the Survey of India maps do not differ very widely, and the layering of all these maps is successful in giving an effect of relief except in the case of a few sheets such as the International 'Kenhardt' sheet and the Indian degree sheet No. 78 P., where the scales do not suit the ground. In the case of India the layer colouring, if we exclude the red layers, is not entirely unnatural. The 32-mile layered map conveys some impression of the generalised characteristics of the zones of altitude of the country by their colours; the greens of the rich alluvial plains, the yellows of the less fertile uplands of the central plateaus and the browns of the frontier hills and lower Himalayas are cases in point. How much of the sense of relief obtained from the lower layers is due to custom and training of the eye it is difficult to say. Much the same colours as those of the international scale are used in the medium and lower layers of the $\frac{1}{500,000}$ map of Sweden, but they are arranged in a different sequence and consequently do not give the same impression of relative altitude. This may be due, in part, merely to the eye being accustomed to the more usual order of layer colours, but it is probably also to some extent inherent in the colours and their sequence. The same map exemplifies the plan of using top red or magenta layers decreasing in strength with altitude, which was followed in the first specification for layering the International Map and has been since abandoned.

Disadvantages of hypsometrical layering.

While it is undoubtedly the case that the application of hypsometrical layering greatly improves the ordinary map on a geographical scale, and even on smaller scale topographical maps of undulating or hilly ground gives valuable information at a glance, the method has certain disadvantages. Layered maps cost more and take more time to reproduce than unlayered maps; the latter is an important consideration in the case of maps for war. Layering detracts, to some extent, from the clearness of a map, and notes such as those marking the positions of troops and works cannot be very clearly marked on it in the field. It involves the surrender of the advantages of using colour to represent surface characteristics, *e.g.*, forests and cultivation and, to eyes trained to the ordinary conventional map colouring, it is sometimes misleading: for instance, officers have complained that they cannot disassociate the green of a layer from an indication of woods. Layers do not give much information as to the detailed shape of the ground unless they are at very close intervals, and, if the intervals are very close, the advantage of the system, namely that of conveying generalised information regarding the altitude of the ground is, to a great extent, lost. Layers that are mere ribbons of colour approximate to contours, over which they have little or no advantage. In an attempt to combine the advantages of layers and contours without the disadvantages of layers, it has been suggested to colour only the contours in each zone of altitude instead of applying the colour in flat washes. This plan would probably prove successful on a map that included only hilly country with steep slopes and that was contoured at close intervals: when tried, it gave rather confused, indefinite results.

Layers on geographical maps.

An approximately perfect method of representing the third dimension on a map has yet to be found, if one is attainable. Probably, for the larger scale geographical maps and smaller scale topographical maps, the best all round results are obtained by using contours at moderately close intervals, supplemented by form-lines and spot-heights to give accurate information as to to the shape of the ground, shade being added merely to give an effect of relief and to render the features more intelligible by massing them, and layers applied only to convey broadly generalised information as to the altitudes and lie of the ground. Map making is an affair of compromise, every elaboration of a map designed to convey special information has some accompanying disadvantage against which it has to be weighed, even if it is merely loss of simplicity and clearness.

Layers on large scale topographical maps.

The English half-inch map of the Ordnance Survey shows conclusively that layering can be used with excellent results on a topographical map. There is, however, considerable difference of opinion as to whether the balance of advantage lies with layered or unlayered maps on ordinary topographical scales and, for the reasons given in Chapter III at page 20 it has been decided not to layer the Indian one-inch maps.

Combination of shading with layers.

Shading as applied to Indian maps (see Chapter III, page 19), gives no additional information but is used merely to make maps more easily intelligible; when applied to a layered map, it undoubtedly detracts from the clearness of the information given by the layers; on the other hand, it undoubtedly makes the map more understandable, especially to people who are not accustomed to use maps a great deal. As explained in Chapter IV, the series of Indian sheets that are layered, namely the $\frac{1}{2\text{ Million}}$, $\frac{1}{\text{Million}}$ and degree sheet series, are published in 2 layered editions, one with, and one without shade.*

* The publication of a layered edition without shade has been discontinued since the above was written, *vide* footnotes on pages 30 and 36.

Appendix I.

Description of some Developments and Improvements in Methods of preparing Tint Plates.

By Major F. J. M. King, R.E.

1. The methods in use in the Photo.-Litho. Office for the reproduction of line work such as is used for maps are as up to date and as satisfactory as the modern methods of Photo.-Lithography will allow: the reproduction of the necessary tints on our maps has however in the past entailed a very great deal of labour, though in the main the results have been fairly satisfactory. It is on account of the vast amount of manual labour expended on producing these tints that a great deal of time and thought have been devoted of late in the Photo.-Litho. Office towards the simplification of this work.

2. In the past if a tint had to be laid down on a zinc plate the portion which was not to receive the tint had to be protected with a film of gum: a print in transfer ink had then to be obtained from the necessary engraved copper tint plate in the Engraving Office and this transfer had to be laid down on the portions of the zinc left unprotected by gum. This "gumming out" of the zinc plate was a laborious enough task when it only had to be done once, but it often happened that the tint did not transfer properly from the transfer paper to the zinc, in which case the zinc plate was spoilt and all the work of "gumming out" had to be done again on a fresh zinc plate.

3. The causes of failure in transferring tints to zinc from transfers from engraved copper plates are numerous, and it will be sufficient if a few of the causes are enumerated. Firstly the copper plates themselves are apt to get damaged when in constant use and scratches are liable to cause flaws in the transfers. Again if the transfers are kept any length of time they become useless. A third cause of trouble is that on a print from a copper plate the ink on the lines or dots forming the tint is actually projecting above the surface of the transfer paper in the form of ridges or small mounds: this projecting ink is apt to get squeezed out flat during the act of transferring the tint to the zinc, thus causing a thickening of the lines or dots and spoiling the tint, and entailing rejection of the zinc plate. In general it may be said that the laying down on zinc of transfers from engraved copper tint plates is an uncertain business involving great risk of spoiling a plate, a matter which becomes serious if the zinc plate has had much labour expended on its preparation prior to receiving the tint. The above, however, is not the end of the trouble, for a tint transferred as described requires very delicate handling both during preparation for the machine and in the machine itself, and is very liable to be spoiled at both those stages.

4. Mr. Vandyke directed his attention to trying to overcome one of the great difficulties mentioned in para. 3, which is caused by the ink on a transfer from a copper plate being raised above the surface of the paper and consequently liable to spread when subjected to pressure during transferring. This difficulty was finally overcome by preparing large size zinc tint plates from transfers from the engraved copper tint plates in the ordinary way. The zinc plate is then etched in relief by biting with nitric acid when it can be rolled up and prints on to transfer paper be made from it. The ink on transfers thus made does not stand up above the surface of the paper, and when these transfers are laid down on to other zinc plates prepared to receive them there is no tendency for the ink to spread.

5. Mr. Vandyke while working on the above discovered that the use of transfer paper of any kind was not necessary. Having prepared a zinc plate with the tint all over it and having etched it in relief he found that by inking it up and placing it face to face with a clean zinc plate the tint could be transferred from one plate to the other by passing the two plates together through a press. It is doubtful if there is any advantage in this direct "plate to plate" transferring, as the transfers prepared as described in para. 4 appear to be satisfactory and avoid wearing out the zinc tint plates, so that they are perhaps to be preferred to transferring from plate to plate, though some workers prefer the latter method.

6. Concurrently with what has already been described a great deal of improvement has been effected towards the same end by a different method. It was noticed that the half-tone plates made by Mr. Taylor's "high light" method such as are used in the Photo.-Litho. Office for hill shade, and which are in effect plates with dotted tints (stipples) on them, would stand rougher usage during preparation for the machine and in the machine than plates which had stipples transferred to them. These half-tone plates

are prepared by the ordinary helio process. This led to the fact being realised that if tints could also be got on to the zinc plate by the helio process they would be much easier to work with than tints laid down by means of transfers. Mr. Vandyke from this evolved the plan of making an artificial negative by hand, on which the portions to be covered with tint were clear glass and the remainder opaque. If this artificial negative be placed face to face with a sensitised helio plate but with a thin film or piece of tracing paper, on which a suitable "tint" or stipple is printed in some opaque medium, between the negative and the helio plate, and an exposure to light made, the tint or stipple will appear on the helio plate on development only on those portions falling directly underneath the clear glass of the artificial negative. It will be seen that this method depends on the interposed film being sufficiently thin to prevent the action of light spreading to these portions of the helio plate underneath the opaque parts of the negative. This method gives very perfect results and is suitable for such tints as the blue of sea areas, &c., cultivation and forest areas. It is not suitable for such tints as the red stipple on roads and villages, as these tints have to be put on to plates on which there is existing work in the form of the lines forming the roads and the outlines of sites, which cannot be protected from harm during the inking up of the stipple prior to development. There is also the difficulty of getting the artificial negative to register accurately with the existing work on the zinc when placing it in the printing frame.

7. The next development was made when it was realised that the work of preparing the artificial negative described in para. 6 was practically doing over again work which had already been done once by the Circle or Drawing Office which prepared the yellow and green colour guides. The question then arose as to whether the work already done on these colour guides could not be utilised to produce without any further hand work a negative to take the place of the artificial negative. Experiments were tried and it was found that if a blue print instead of a black was used on which to prepare the colour guides and if a sufficiently strong gamboge and Hooker's green No. 2 were employed in their preparation, the colour guides themselves could be photographed to produce negatives to replace the artificial negatives. This procedure has consequently been adopted and is now in general use throughout the Department.

8. A large amount of thought and many experiments have been devoted towards producing the thin transparent screens with stipples or tints on them, referred to in para. 6, for use between the negative and the helio plate.

Appendix II.

A note on a new Method of Preparing Layer Plates for the Layered Maps of India.

By Major F. J. M. King, R.E.

Old Method.

1. The principle in use in the printing of layers for Survey of India maps is, with the exception of the yellow plate, to prepare each layer plate to print three different tints of the same colour, namely a light tint, a medium tint and a solid tint. The yellow plate, however, is only made up to print two tints, a light tint and a medium tint. A reference to the diagram will make the matter clear.

2. The method which has been in use up to date, of preparing these various layer plates, is both laborious and not particularly satisfactory. To get an idea of the amount of labour expended on the preparation of a full set of layer plates, it will be sufficient to consider the labour involved in the preparation of one plate, and imagine that multiplied by the number of layer plates. A fair example will be to consider the labour and time formerly expended on a plate such as the "first brown" plate in the diagram.

3. First of all an off-set (or image in black powder) of the detail and contours combined, had to be laid down on a clean, grained zinc plate. The whole of the plate below that part which was to receive the light tint now had to be carefully gummed out by hand with a brush. In addition, all areas above the lower limit of the light tint which were not to receive a layer tint, such as lakes and double-lined streams, were also gummed out. The upper limits of both the light and medium tints then had to be marked on the plate by means of a line scratched into the plate with a sharp point. A tint transfer from a copper plate consisting of fine engraved lines was then laid down on the plate, passed several times through a hand press, and finally washed, leaving the tint on the ungummed portion of the plate. The whole of the area of the plate which had to print either a light, a medium or a solid tint was by this method covered with fine parallel lines which formed the light tint.

4. The whole of the plate now had to be painted out with gum again, only leaving exposed those portions which were to print the medium and the solid tint, the lower of the two lines already scratched on to the plate forming the guide for the draughtsman. The portion of the plate which was required to print the light tint was thus protected by gum from receiving any further transfers. Another tint transfer was now laid down with the lines of the tint crossing at right angles the lines of the tint which was first laid down. After washing off the second transfer, the light and the medium tints were complete. The portion of the plate which was to print the solid tint was however still covered with the cross lines forming the medium tint; this portion therefore had then to be painted in solid by hand, down to the higher of the two lines previously scratched into the plate.

5. It will be seen from the above that, even if all went well, it was a laborious process. It was, however, the exception rather than the rule for everything to work satisfactorily; for instance, it often happened that a transfer did not go down properly; in which case the whole of the work already on the plate was wasted and had to be done over again. Even if a plate appeared to be satisfactorily prepared it was very often spoilt in printing, as plates with these fine tints *transferred* on to them are very delicate and will not stand as much as when the tint has been put on to the plate *photographically*.

When it is considered that the above labour was necessary for the preparation of one plate, some idea can be gathered of the amount of time and labour involved in the preparation of a full set of such plates.

New Method.

6 The first stage of the new method is the preparation of what I have termed the "Layer Original". For this purpose a blue print of the detail and contours combined is made on a piece of any good quality smooth surfaced paper which has been previously mounted on zinc. The portions of this blue print corresponding to the black portions on the diagram attached are then painted in solid with opaque Indian ink, using the layer guide which has been prepared by the Circle or Drawing Office as an assistance to the draughtsman. Certain of the contours also have to be inked up with a fine black line. In the case referred to in the diagram the 1,000, 3,500, 6,000 and 12,500 feet contours have to be inked up to show the limits between contiguous portions which are left white on the layer original. In the case of maps in which every contour bounds a layer (*i.e.*, on which there are no intermediate contours) the inking in of the contours by hand can be saved by printing the contours in black instead of in blue on the print on which the layer original is prepared. Any areas such as lakes, double lined streams and perpetual snow areas which should not receive a layer tint, are, if they fall within the blackened areas, left white; if they fall in the areas left white they are outlined by a fine black line.

7 The layer original having been completed, it is sent to the Photo. Branch where as many negatives* as there are to be layer plates are made of it, the negatives, however, being made through a half-tone screen. The exposure for these negatives is so regulated that the black portions of the layer original come out on the negatives as clear glass covered with small opaque dots, while the white portions come out as an opaque ground covered with small transparent dots.† The inked-up contours and areas which are to receive no layers such as lakes, double lined streams and snow areas of course appear clearly on the negatives.

8. One negative is now selected for each layer plate and the negatives are sent to the Retouching Section for duffing. Considering the first brown plate (*vide* diagram):—This negative is duffed from the 2,000 feet contour downwards; above this no duffing is necessary except to duff out lakes, double lined streams and perpetual snow areas. The second brown negative is similarly treated except that it is duffed from 3,500 feet downwards, and likewise with the first and second red negatives which are duffed from 6,000 feet and 12,500 feet downwards respectively. The yellow negative, however, is duffed from 2,000 feet upwards and from 1,000 feet downwards, while all sea areas and areas above 1,000 feet are duffed out from the green negative. Register marks are cut in at the corners of all the negatives, and helio plates are made from all the negatives.

9. Each helio plate has now had two tints (the light tint and the medium tint) produced on it photographically, out of the three tints which it has to print. It now only remains to paint in those portions of each plate which are to print solid, still leaving blank those portions such as lakes, double lined streams and snow areas which have no layers on them. This completes the preparation of the layer plates.

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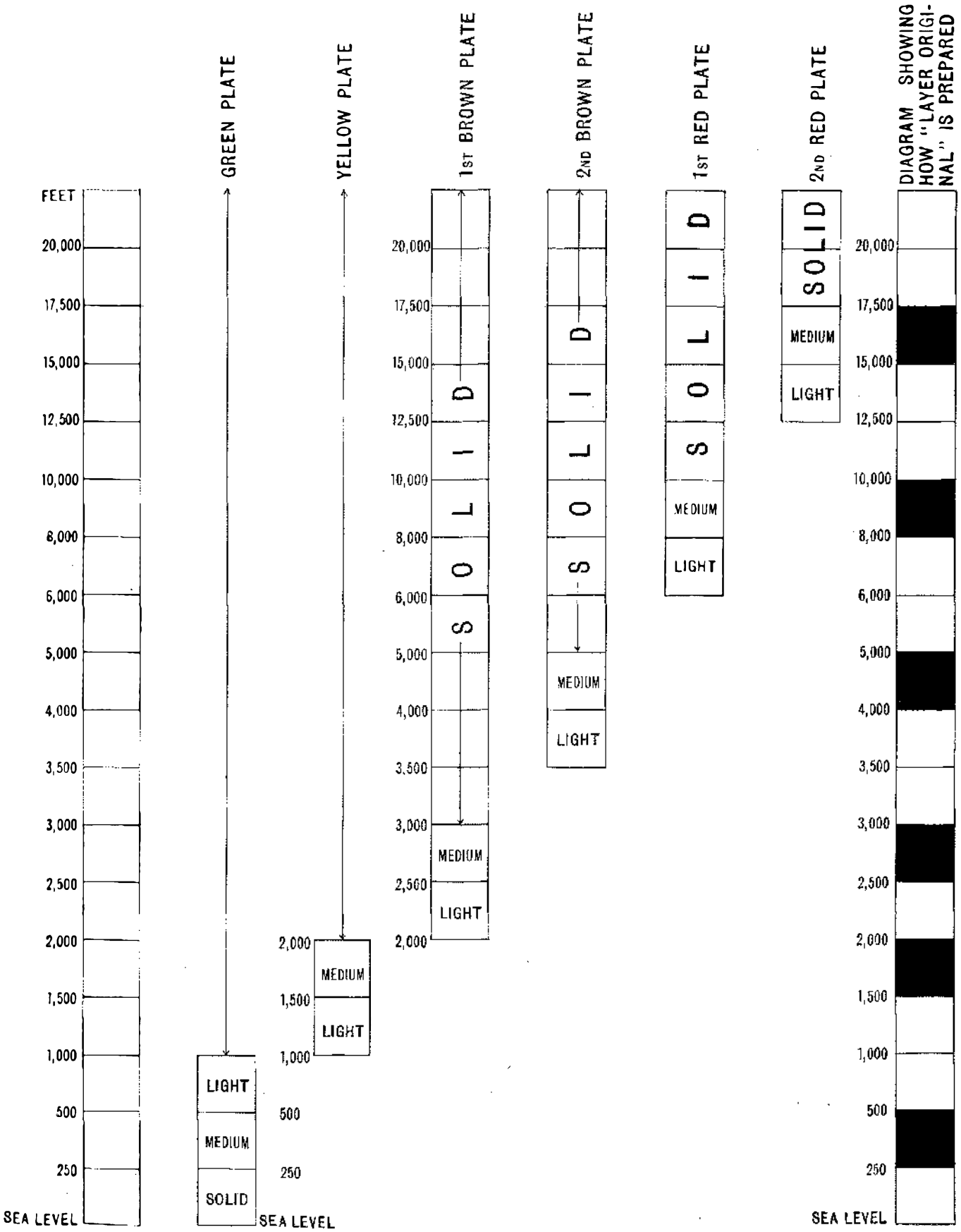
* Since the above was written the practice has been adopted of only making one screen negative in the camera, as many duplicates of it as necessary being made from it by the Powder Process. (See footnote on page 1).

† The shape and formation of these dots can be varied by using different shaped stops in the camera: this is still the subject of experiment in the Photo.-Litho. Office.

DIAGRAM TO ILLUSTRATE APPENDIX II.



LIST OF PLATES.

GEOGRAPHICAL MAPS ON SCALES LESS THAN $\frac{1}{\text{MILLION}}$.

GEOGRAPHICAL MAPS ON SCALES OF $\frac{1}{\text{MILLION}}$ AND 16 MILES TO 1 INCH.

TOPOGRAPHICAL MAPS ON SCALES OF 4 MILES TO 1 INCH AND SMALLER SCALES.

TOPOGRAPHICAL MAPS ON THE SCALE OF 1 MILE TO 1 INCH.

MAPS AND CHARTS FOR SPECIAL PURPOSES.

NOTE.—Many of the above plates were printed before the letterpress of this paper. In the footnotes to Plates IX, X, XVII and XVIII reference is made to the publication of three editions of certain maps, *e.g.*, with contours and shade, with layers and shade and with layers only. The publication of the edition with layers only has been discontinued of late and only two editions of these maps are now printed.